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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

REGION IN THE VICINITY OF THE

BOW AND BELLY RIVERS,

NORTH-WEST TERRITORY.

EMBRACING THE COUNTRY FROM THE BASE OF THE ROCKY
MOUNTAINS EASTWARD TO LON. $110^{\circ} 45'$, AND
FROM THE 49TH PARALLEL NORTHWARD
TO LATITUDE $51^{\circ} 20'$

BY

GEORGE M. DAWSON, D.S., F.G.S.,

ASSOCIATE ROYAL SCHOOL OF MINES.

ASSISTED BY

R. G. McCONNELL, B.A.



PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

TO ALFRED R

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OTTAWA, MAR

TO ALFRED R. C. SELWYN, Esq., LL.D., F.R.S.,

Director Geological and Natural History Survey of Canada.

SIR, I beg to present herewith a report on the region in the vicinity of the Bow and Belly Rivers, embracing the southern part of the District of Alberta and a portion of the western part of Assiniboia, with illustrative maps. This district is the first in the North-west Territory of which a systematic and proximately complete examination has been made, and is of special importance in consequence of the proximity of its valuable coal and lignite deposits to the line of the Canadian Pacific Railway.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, March, 1884.

NOTE.

Most of the elevations stated in this report are the result of aneroid barometer observations, based on the height of Fort Benton, which is assumed at 2,700 feet. General Hazen having kindly furnished a copy of the regular barometric observations at that place, the whole of the aneroid readings have been carefully compared with these. Where several observations have been obtained at a single locality, and separately calculated, the results generally agree very closely, and the limits of error are probably, in all cases, within fifty feet. A few points on the line of the Canadian Pacific Railway have been obtained, since the date of the explorations here reported on, by actual instrumental levelling.

Where not otherwise stated, the bearings given throughout are with reference to the true meridian.

G. M. D.

This report, and part of the area described, is that tributary to the river of the latter, the valley of the Cheyenne. It includes a portion of the section from the base of the mountains an area of about 100,000 acres, based on the softest Laramie. This district has been subjected to a coal survey and was selected for a value of its coal deposits. A mental railway route, of prairie character and might likely serve the light of which, the foot-hills of the mountains in no wise disappointed to be wide-spread the detail of its geology desired, most of its purposes for practical purposes for Such uncertainty

REPORT
ON THE
COUNTRY IN THE VICINITY OF THE
BOW AND BELLY RIVERS,
NORTH-WEST TERRITORY.

This report, and the maps which accompany it, cover the greater part of the area drained by the Bow and Belly Rivers, and portions of that tributary to the Red Deer and Milk Rivers. With the exception of the latter, the whole of its waters eventually reach the South Saskatchewan. It includes the southern part of the district of Alberta, with a portion of the south-west of the neighbouring one of Assiniboia, and from the base of the Palaeozoic rocks of the mountains eastward, includes an area of about 26,960 square miles of prairie and plateau country, based on the softer and newer formations designated as Cretaceous and Laramie. This district is the first in the western territory which has been subjected to a systematic and proximately complete exploration, and was selected for this purpose because of the known and reported value of its coal deposits, and its relation to the adopted transcontinental railway route. It further appeared, that from its general prairie character and the number of the river-valleys traversing it, it might likely serve geologically as a typical region, in which the order and succession of the various formations could be determined, and in the light of which, future explorations in the great plains and in the foot-hills of the mountains might be carried on. Its investigation has in no wise disappointed these expectations. The coal deposits have proved to be wide-spread and practically inexhaustible, and while in the detail of its geological structure much addition is yet to be desired, most of its main features are clear and easily read, and it is hoped that the present geological map and report may answer all practical purposes for a number of years to come.

Such uncertainty as to the details of geological structure as may still

Region covered
by report and
maps.

Area.

Importance of
the region.

Circumstances rendering geological investigation difficult.

remain is due chiefly to two circumstances which may be briefly alluded to. While the river-valleys generally afford fine sections, great intervening tracts are so thickly drift-covered that the underlying rocks seldom come to the surface, and absolute certainty as to the position of the outcrops of certain beds and coal seams in these regions can only be arrived at by boring operations. Again, in the foot-hill region, where the beds are sharply folded and even overturned, and other accidents occur to complicate the structure, while it is doubtless possible to trace out the subdivisions of the Cretaceous and Laramie with greater completeness, this would require so much time and labour that it has not been judged advisable at present to undertake it, in view of the great importance of defining and publishing its general structures.

History of its geological exploration.

The first geological notes on the district are those in Dr. Hector's reports, based on his explorations in the North-west as a member of Captain Palliser's expedition in 1859. No addition was made to these till in 1874 the writer examined the country near the 49th parallel as geologist to H. M. North American Boundary Commission. In 1881 the entire summer season was spent by me and my assistant Mr. R. G. McConnell, B.A., on the area of the accompanying map, and in 1882 Mr. McConnell, having wintered at Calgary, continued the exploration independently. In 1883 the month of June was devoted by me to the further examination of a number of localities on the southern part of the map, in regard to the structure of which doubts still remained, and Mr. McConnell completed the traverse of the portion of the Red Deer included on the sheet. Additional light on the general geology has also been obtained through Mr. McConnell's subsequent work in the adjacent region to the east. While the main geographical outlines of the map are based principally on the instrumental surveys of the Dominion Lands Branch, much of the topography has been added from our own surveys, I would mention especially in this regard the area of the foot-hills from the North Fork of the Old Man to the Elbow Rivers which was mapped by Mr. McConnell in 1882, and had not previously been penetrated by any survey lines. Nearly all the trails and travelled routes were also laid down from our own odometer surveys, and canoe traverses of the Bow, Belly and St. Mary, part of the Old Man, and those portions of the Red Deer and South Saskatchewan, included on the map, have added much to the topography previously delineated on these streams.

Data of the map.

MAIN TOPOGRAPHICAL FEATURES OF THE DISTRICT.

Three natural divisions.

The district may be divided naturally by its physical characteristics into the following parts enumerated in order from east to west:—(1) Plains and low plateaus. (2) The Porcupine Hills. (3) The foot-hills.

CARSON.]

The Rocky Mountains not included in their structure.

The routes were thus approximately twice traversed and examined.

Measurements

Distances

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Measurements

The bearings given are with reference to the north.

In conformity with the Rocky Mountain portion of the district which nearly bisects 3,000 feet in altitude, excepted in the country exceeds considerable tract most important forms a raised surface in the vicinity of the 49th parallel, 4,000 feet in altitude.

an insular area of separated from the extreme north upon the lower part.

Along the base of the mountains leave the Paleozoic feet. The Rocky Mountains parallel, where the distinct and almost range frequently elevation of over at some distance mountains is to the hills which here present little if at all influence.

The Rocky Mountains, which form its natural western boundary, are not included in this report, except in so far as incidental mention of their structure may be necessary.

The routes within the area of the map, traversed and examined by myself and Mr. McConnell during the progress of the exploration, may be thus approximately stated, no account being taken of those which were twice traversed or passed over a second time without measurement and examination.

Measured by odometer.....	2315 miles.
Distances estimated, and checked by observations for latitude.....	835 "
Measured by pacing.....	275 "
Total.....	3425 "

The bearings given throughout this report, unless otherwise qualified, are with reference to the true meridian.

In conformity with the general eastward slope of the plains from the Rocky Mountains, the eastern is low as compared with the western portion of the district here described. East of the 113th meridian, which nearly bisects the map, a great portion of the plain is less than 3,000 feet in altitude, while westward from the same line, with the exception of inconsiderable tracts along the river-valleys, the whole country exceeds this elevation. East of the above line, however, considerable tracts still rise above the 3,000-foot contour-line. The most important of these lies in the vicinity of the Milk River, and forms a raised southern border to the district, the whole region in the vicinity of the 49th parallel west of the 111th meridian exceeding 3,000 feet in altitude. To the north, the plateau of the Rocky Buttes forms an insular area of considerable extent above this contour-line, being separated from the plateaus to the west by the Snake Valley, while at the extreme northern edge of the map the Hand Hills again encroach upon the lower plains.

Along the base of the mountains, the elevation at which the rivers leave the Palaeozoic rocks is pretty constant, and averages about 4,300 feet. The Rocky Mountains, for some distance north of the 49th parallel, where the foot-hills are comparatively inconsiderable, form a distinct and almost mural eastern front, the peaks of the first or outer range frequently attaining a height of 6,000 to 7,000 feet, while an elevation of over 9,000 feet is not infrequently reached by the summits at some distance back. Further north, the eastern outline of the mountains is to some extent masked by the high and crowded foot-hills which here press upon them, but the altitude of the summits is little if at all inferior.

Such being the outlines of the region in regard to elevation, a brief description of the general features of its three natural divisions as above defined may now be given.

General character of the three divisions.

THE PLAINS.

The plains.

Drainage.

Plateaus.

The plains proper may be considered as extending westward to the foot-hills near the St. Mary River in the vicinity of the 49th parallel, but further north, find their western limit at the base of the Porcupine Hills. Their surface is generally undulating or rolling, though in some localities considerable tracts occur which are almost perfectly level. The undulations vary much in amount locally, but are seldom—and then only in limited areas—entitled to be called hills. Deep, trough-like valleys, occupied by rivers, or, in some cases, by quite inconsiderable streams, and then denominated “coulées” trench the plains at intervals, but wide intervening areas are entirely destitute of drainage channels, the rainfall collecting in lakes, or in the innumerable small pools and sloughs which dot the surface, but which frequently dry up completely during the summer. Rising above the general level are a number of elevations which are generally called “ridges,” but are properly speaking plateaus. The heights of these seldom exceed by more than one hundred or two hundred feet that of the surrounding plain, and their slopes are usually very light. As viewed from a distance, however, in this flat country, they are frequently conspicuous objects, and are generally in close and evident connection with the geological structure. The more important of these may be enumerated as follows:—Milk River Ridge, west of the MacLeod-Benton trail and north of the Milk River, average elevation 4,100 to 4,200 feet. Belly Butte and associated ridges between the St. Mary and Upper Belly Rivers, running eastward into Wild Turnip Hill. The Chin, on Chin Coulée, forming the western end of a diffuse plateau. Plateau south-east of Lake Pakow-kī, and high ground stretching eastward from the Three Buttes. Bull's Head, east of Seven Persons River, forming the southeastern front of the Peace Buttes. Black Spring Ridge, elevation 3,550 feet. The Thigh Hills. Buffalo Hills, 3,850 feet. The Rocky Buttes, about 3,100 feet. Spy Hill, Carcass Hill, Spring Hill, and Little Rolling Hills. Outer and Inner Rainy Hills, about 2,700 feet. Wintering Hills, about 3,000 feet. The Hand Hills, with, according to Dr. Hector, an elevation of 3,400 feet.

Uniformity of surface.

The general uniformity of the surface of the country is largely due to the covering of boulder-clay and other drift deposits. These have been apparently laid down in greatest thickness in the pre-existing hollows, while the higher plateaus are comparatively thinly covered; and the result has been the general levelling up of the surface, and the produc-

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tion of wide flat Cretaceous and Tertiary banks of rivers remarkable uniformity of the soil, is usually clay. It may be tinted, and mingled with gravel, or is most usually fine sand, or altogether washed by fine water-deposited sand-hills, having only a few scattered Sand hills north of the Belly Rivers. Near the mouth of the Peigan Sand Hills River.

In a few places but these areas of boulders is generally owing to some local materials of the country thus shows how the deposition of

Speaking generally the places are eminently is probably too serious is almost uniform desert-like character known as “buffaloes” mid-summer, but is not a good pasture both about the lower end of all the plateaus about growth of grass sparse and surrounding the a few years since, they have now practically been replaced by catt

The entire region is treeless, and except steep-sided coulées,

tion of wide flat plains in the less elevated tracts. The underlying Cretaceous and Laramie rocks are seldom seen except in the scarped banks of rivers and streams. The same circumstance has caused a remarkable uniformity in the general character of the soil, which, below the sod, is usually composed of the rearranged materials of the boulder-clay. It may be described generally as a clayey loam, of brown or grey tint, and mingled locally with a varying proportion of gravel. Gravel is most usually found in the subsoil in the higher tracts, and is almost or altogether wanting in many of the lower, which are characterized by fine water-deposited loam. No large areas of loose sandy soil, or sand-hills, have been observed in this district, the most extensive covering only a few square miles, of these the following may be noted:— Sand hills north and east of Lake Pá-kow-kí. About forks of Bow and Belly Rivers. In the South bend of the Belly east of Little Bow. Near the mouth of the Little Bow. The Drifting Sand Hills, and the Peigan Sand Hills west of Blackfoot Crossing and near the Bow River.

In a few places the surface is pretty thickly strewn with boulders, but these areas are quite inconsiderable, and the prominence of the boulders is generally to be traced to the removal by denudation,—owing to some local circumstance—of a considerable depth of the finer materials of the drift. The general absence of boulder-strewn tracts thus shows how small must have been the effect of denudation since the deposition of the boulder-clay and other glacial materials.

Speaking generally, the soil may be described as fertile, and in some places is eminently so, but over a large part of these plains the rainfall is probably too scanty for the successful growth of crops. The surface is almost uniformly grassed, and no tracts of an absolutely barren or desert-like character occur. The grass is usually the short crisp variety known as “buffalo grass,” which becomes to all appearance dry about mid-summer, but is still green and growing at the roots, and forms nutritious pasture both winter and summer. In some particularly dry areas about the lower Bow River, the grass becomes scanty, but on almost all the plateaus above enumerated it is particularly good, while a heavy growth of grass suitable for hay is found in many of the river bottoms, and surrounding the numerous lakes and sloughs. This whole region, a few years since, contained numerous herds of buffalo, and though these have now practically disappeared, it will not be long before they will be replaced by cattle and horses.

The entire region of plain included on the map may be characterized as treeless, and except in the river valleys, or here and there in some steep-sided coulees, no arboreal or shrubby growth of any kind exists.

The Porcupine Hills.

THE PORCUPINE HILLS.

Physical features.

Prairie and wooded areas.

Cattle country.

The Porcupine Hills, properly so-called, extend from the north bank of the Old Man River, west of Fort MacLeod, to the head-waters of Mosquito Creek, a distance of fifty-five miles in a north-north-west direction. Their greatest breadth is pretty uniformly maintained at from eighteen to twenty miles. The Hog's Back or Sitoko-pawaghko, south of the Old Man, is really, however, a part of the same range, while to the north it is continued by more or less isolated areas of high plateau to the Bow River, and beyond that stream by the Nose Hill.

The Porcupine Hills consist of rocks forming the upper part of the Laramie, and mark the axis of a wide synclinal. Mr. McConnell, who examined this region in 1882 thus describes the physical features of the hills proper:—

"The hills are highest near the southern end, where they rise about 2,000 feet above the plains to the east (at least 5,000 feet above the sea) and about 1,500 feet above the valley lying along their western base. To the north they become much lower, and near Highwood River are only about 400 feet above the general level of the country."

"The surface of the hills is very rough, and is generally cut up by the deep and wide valleys of numerous small streams. The great valleys which even the most insignificant of these streams have excavated, give evidence of an erosive activity at one time, far exceeding anything which is now going on. The grassy slopes which nearly all the valleys present at the present day, showing how small the denudation in progress is."

"The principal drainage of the hills is to the east and south, in consequence of the difference of elevation of the country east and west of them, which amounts to over 450 feet. Viewed broadly, their surface is composed of the broken remnants of a wide plateau with an eastward inclination."

The lower slopes of the hills on both sides are open grassed land. At a somewhat greater elevation scattered trees begin to occur, but it is only on some of the higher western points that any areas of continuous woodland occur. The Hog's Back to the south carries no wood, but on the isolated plateau areas north of Highwood River, thickets and groves begin to appear in a few places, in consequence of the greater humidity of the climate in that region.

The eastern margin of the Porcupine Hills is nearly identical with the western border of the buffalo-grass country previously described. In consequence of the greater rainfall met with on approaching the mountains, the buffalo-grass is here replaced by the more luxuriant bunch-grass, and within the area of the Porcupines and their north-

ward and south of the entire No

Stretching also is a region with the "Foot-hills," and disturbed regions in which these impressions escape the notice with vegetation crests formed by with parallel valleys which have their channels to the here fresh from the rocky beds, and which is not without timber (generally some of the more

The ridges, with nearly complete mountains, and geologically distinct Mary, Upper Bow Pincher Creek, M about thirteen miles on the Highwood Bow River, two mountains at the accounts for the

For twenty-four tains from the and inconspicuous land, except on is covered with along the river hills become especially in the the Bow River is more or less of the River some of the

ward and southward extensions some of the best cattle ranching country of the entire North-west is situated.

THE FOOT-HILLS.

The foot-hills.

Stretching along the whole length of the base of the Rocky Mountains, is a region with peculiar characteristics which is appropriately named the "Foot-hills." This is conterminous with a belt of sharply folded and disturbed rocks of Cretaceous and Laramie age, and the character which these impress on the region is so well marked that it can scarcely escape the notice of any traveller. Long ridges, sometimes covered with vegetation to the summit, in other cases showing projecting rocky crests formed by the outcrop of the harder sandstone beds, alternate with parallel valleys in which the smaller streams flow, while the rivers which have their sources in the mountains have carved for themselves channels to the plains beyond, nearly at right angles. The streams here fresh from the mountain snows are limpid, flow over gravelly and rocky beds, and are often full of fine trout. That part of the region which is not wooded is covered with luxuriant bunch-grass, and fine timber (generally the Douglas fir) exists in considerable quantities in some of the more retired valleys.

The ridges, with the strike of the rocks which they indicate, show a nearly complete parallelism with the base of the Palaeozoic rocks of the mountains, and follow it in its light sinuosities. The width of the geologically disturbed region and of the foot-hill belt is, on the St. Mary, Upper Belly and Waterton Rivers, about sixteen miles; On Pincher Creek, Mill Creek and the southern branches of the Old Man, about thirteen miles; on the north fork of the Old Man, twelve miles; on the Highwood River and its tributaries, sixteen miles; and on the Bow River, twenty-seven miles. The base of the older rocks of the mountains at the last named locality, falls back in a wide bay, which accounts for the increased width of the foot-hills at that place.

For twenty-four miles north-westward along the base of the mountains from the 49th parallel, the foot-hills are comparatively low and inconspicuous, and there are no connected areas of wooded land, except on the upper part of the Belly Valley. The country is covered with fine bunch-grass, and the woods are chiefly massed along the river valleys. From this point northward the foot-hills become well developed, there are considerable wooded tracts, especially in the immediate vicinity of the mountains, and before the Bow River is reached a large part of the foot-hill region is more or less densely wooded. About the branches of Highwood River some of the foot-hills become so bold as almost to rival the outer

Agricultural
and grazing
lands.

range of the mountains in height, and a few districts have become nearly inaccessible from the quantity of burnt and fallen forest.

The whole of the open country in the foot hills is admirably adapted for grazing purposes, the rainfall is ample, and in consequence of the greater humidity of the climate, the soil to a considerable depth usually consists of a rich, black, vegetable mould. In the lower valleys which exist in the Porcupine Hill region and its southern and northern continuations, and in those of the foot-hill belt, the greater part of the land really valuable for agricultural purposes in the district now reported on, lies. Such at least is my opinion, founded on the results of farming already initiated, and the comparison of the different classes of country met with in this district with those of a similar character, and bearing a similar flora elsewhere. The greater part of the Porcupine Hills proper, together with the higher regions of the foot-hills, though otherwise well adapted to agriculture, are too frequently subject to early and late frosts. Where agriculture succeeds, the crops produced are eminently satisfactory.

Pastoral wealth
of the district.

It would thus appear that apart from the mineral wealth of the district, and particularly the inexhaustible stores of coal and lignite which are fully described in a succeeding portion of this report, the resources of the country are mainly pastoral, and there are few regions which can excell, or indeed equal this one in that respect. The stocking of this district may be said to have been systematically begun in 1881, and it is now being rapidly occupied.

Climate.

A few words may be added in regard to climate. We are yet without full and trustworthy observations of the temperature and rainfall, but these will doubtless be supplied ere long by the meteorological service. The climate of that part of the district included under the general title of Plains, probably closely resembles that of a large portion of the southern part of the great plains of the North-west Territory. The total annual precipitation of moisture is evidently small, the summer heat is frequently great during the day, and is quite sufficient in intensity and duration for the ripening of all ordinary grains, wherever sufficient moisture is found for their healthy growth. The winter is severe, and the exposed and treeless character of the country causes its rigor to be more keenly felt, but there is no reason why tree-planting should not succeed at least in the river valleys and on broken ground, even in many of the dryer portions of the plains; and wherever the rainfall is sufficient for crops, the growth of trees with proper precautions is undoubtedly possible. It is stated that the winter climate in the neighborhood of Fort MacLeod is milder than elsewhere, and though little instrumental proof of this can yet be adduced, it may probably be the case, and arise from the less elevation of that part of the district, combined

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with its vicinity entire district, its amount and tracts receiving altitude. The undoubtedly a and this—up average height, particularly the important part in the mountain on the contrary mountain barrier comparatively known physical lution and evap feely attained range to the va are generally in elsewhere discuss the present report

GENERAL

In this division given of such ph to be of economic tracts intervening to north, the arrangement succeeding strictly

MILK

Milk River rising crossing that line north of the parallel its minor flexures. the present map. map, it recrosses It is known as K and possesses some

A * Report of Progress, G

with its vicinity to the mountains. The snow-fall is light over the entire district, and in the Porcupine Hill region and foot-hills, its amount and persistence is largely a matter of elevation, the higher tracts receiving and bearing much more snow than those with a less altitude. The country in the neighbourhood of the mountains has undoubtedly a milder climate than that remote from them, and this—up to a certain point—notwithstanding its greater average height. The set of the aerial currents from the westward, and particularly the strong westerly winds known as “Chinooks” play an important part in this amelioration. It is not the case that low passes in the mountains account for the influence of the westerly winds. It is on the contrary the fact that the passage of these winds over a high mountain barrier, and their subsequent descent into low ground in a comparatively dry and warm state, in correspondence with well known physical laws, enables them to affect the rapid dissolution and evaporation of the snow. This result is most perfectly attained where the descent from the summits of the range to the valleys below is greatest, and as the lowest tracts are generally in the river-valleys, is there most marked. As I have elsewhere discussed this subject pretty fully,* it is not proposed in the present report to enter into it at length.

Mild climate
near the
mountains.

Chinooks.

GENERAL DESCRIPTION OF THE DISTRICT.

In this division of the report, a general systematic description is given of such physical features and facts, in the district as appear to be of economic importance. The various river-valleys, and the tracts intervening between them are described in order from south to north, the arrangement being the same with that followed in the succeeding strictly geological section of the report.

Orders
followed.

MILK RIVER AND COUNTRY IN ITS VICINITY.

Milk River rises in the foot-hills south of the 49th parallel, and, crossing that line near the 113th meridian, pursues a course not far north of the parallel for a distance—without taking into consideration its minor flexures—of one hundred and three miles, within the limit of the present map. A short distance beyond the eastern edge of the map, it recrosses the 49th parallel on its course to join the Missouri. It is known as Ke-nuh-si-suht or Little River by the Blood Indians and possesses some peculiar and interesting features. In that part

General course
of Milk River.

Tributaries
unimportant.

* Report of Progress, Geological Survey, 1879-80, p. 77 B.

part of its course above defined it receives besides the South Branch which is about equal to the main river or North Branch, a few small tributaries from the south, of which Red Creek is the most important, and probably holds running water at all seasons. The tributaries from the north are all very small brooks, even at times of high water. The river cannot be considered as navigable even for canoes. It is rapid and in some parts of its course very tortuous on a small scale, but in many places difficult to cross on account of quicksands. In the season of 1874—a more than usually dry year—we found its bed completely dry in some places a few miles south of the 49th parallel, a short distance east of the limit of the present map. Between the 113th and 112th meridians, the country has a general northward slope, which, on the MacLeod-Benton trail, from the high southern edge of the Rocky Spring Plateau to the 49th parallel—a distance of twelve miles—amounts to 405 feet, or about thirty-four feet to the mile. The wide clayey and barren plain southeast of this plateau has an elevation several hundred feet less than that of the bed of the Milk River in the same longitude. Between the MacLeod-Benton trail and the flank of the West Butte, near the 49th parallel, are several wide irregular trough-like valleys, holding very small streams, or entirely without flowing water, for which the present conditions of the country fail to account. The drainage of the northern flanks of the Buttes, which is very small in amount, also finds its way to the Milk River by a system of valleys, some of which are of considerable depth.

In the report on the Geology and Resources of the 49th Parallel,* I have described the general aspect of the country south of the Milk River, and west of the West Butte in the following terms:—As compared with the tract east of the Butte and south of the Cypress Hills, it improves in appearance, and shows evidence of a greater rainfall, and the cactus, grease-wood and *Artemisia* cease to appear. It is generally much broken, but shows evidence of a former more elevated surface, in somewhat extensive flat-topped hills, which, when ascended, are found to be nearly of equal height, and show much drier and more gravelly soil than elsewhere found in the region. There is usually a close thick growth of grass, and the swamps and sloughs, which are numerous, generally hold grasses and *Carices* to the exclusion of the rushes formerly most abundant.

Three wide valleys join the Milk River from the north—the Lonely Valley, Verdigris Coulee, and the Lake Pa-kow-kī Coulee. The two first carry very small streams and the latter is dry. In fact, at a dis-

* A very limited edition of this report was issued by the Boundary Commission, and as it is now completely out of print, I have not hesitated to incorporate such parts of it as refer to the district here under discussion.

tance of a few below the level which it first crosses lower than the the mouth of L hundred and se the MacLeod-B thirty-two feet ever, in the Lak lake reaches to feet lower than into the lake, and ing to the preser

The Milk River plateau region, o and other elevat point at which it tion than those c when these are greater part of t the Rocky Spri

The country in 113th meridian to may be described lower tracts and some of the hig itself probably and about 300 f invariably produ sufficiently long is elsewhere mo grassed, and dott tute a fine summ is met with exce

For about seve bly wide with low of wood. Thene half a mile in w is rather short an which is a trougl holds several lak Milk River valle Butte. The bot

tance of a few miles north of the Milk River, the whole country is below the level of its bed. Thus, five miles north-west of the point at which it first crosses the 49th parallel, the plain is fifty-seven feet lower than the nearest part of the river. Twelve miles north-west of the mouth of Lonely Valley, beyond the Milk River Ridge, it is one hundred and seventy feet lower; eight and a half miles north-west of the MacLeod-Benton trail-crossing, nearly on the course of the trail, thirty-two feet lower. The most remarkable instance is found, however, in the Lake Pā-kow-ki Coulée, where the south-western arm of the lake reaches to within three and a half miles of the river, but is eighty feet lower than it. Here, by a small cutting, the river might be turned into the lake, and would then flow round by Many Berries Creek, returning to the present valley near its intersection with the 49th parallel.

The Milk River thus actually occupies the central line of a long broken plateau region, of which the Milk River Ridge, the Rocky Spring Plateau and other elevations, constitute the higher parts, and its waters at the point at which it first crosses the 49th parallel are at a greater elevation than those of any of the other large streams in the district, except when these are in the immediate vicinity of the mountains. The greater part of the Milk River Ridge, and a considerable portion of the Rocky Spring Plateau exceed 4,000 feet in elevation.

Peculiar
features of
Milk River.

The country in the immediate vicinity of the river-valley from the 113th meridian to the point at which the MacLeod-Benton trail crosses, may be described as generally affording fair to good pasturage. The lower tracts and valleys are invariably covered with good grass, while some of the higher tracts are gravelly and rather bare. The valley itself probably averages about a mile in width—though narrow and about 300 feet deep for a few miles below Lonely Valley—and invariably produces very fine grass, of which a considerable portion is sufficiently long to be cut as hay. The Milk River Ridge, to the north, is elsewhere more fully described. Its surface though high, is well grassed, and dotted with numerous sloughs and pools. It will constitute a fine summer grazing-ground. No arboreal or shrubby vegetation is met with except a few bushes in one or two deep coulées.

Valley west of
MacLeod-
Benton trail.

For about seven miles east of the trail-crossing, the valley is remarkably wide with low sloping banks in many places, but is equally destitute of wood. Thence to the mouth of Verdigris Coulée it seldom exceeds half a mile in width, and the pasturage to the north for some distance is rather short and indifferent. No wood occurs in the Verdigris Coulée, which is a trough-like valley about three-quarters of a mile wide, and holds several lakes in its course. From this point, for eight miles, the Milk River valley expands, and is about a mile wide north of the West Butte. The bottom is well grassed, and small groves of cottonwood

MacLeod-
Benton trail to
Dead Horse
Coulée.

occur in it. Sandstones, which weather into monumental and fantastic forms, elsewhere fully described, border its sides. The pasturage in the plains immediately to the northward may be characterized as fair, though occasional patches of cactus occur.

Dead Horse
Coulée to Pa-
kow-ki Coulée.

The river next turns abruptly to the north, in a comparatively narrow valley, while a wide trough, evidently that formerly occupied by the stream, and known as Dead Horse Coulée, continues in the main direction for six miles when it is rejoined by the river. Thence to the Pa-kow-ki Coulée the valley is at least fifty and sometimes over one hundred feet deep. It continues wide, and the edge of a low diffuse plateau runs nearly parallel to it some miles to the north. The country between the river and the plateau-edge affords fair to good pasturage, and pools and swamps are in some places frequent. The level of the plateau further to the north slightly exceeds 3,000 feet, with an undulating surface, and generally affords a good close growth of buffalo-grass. It is diversified by numerous small pools and swamps, most of which become dry before the end of the summer.

From Pa-kow-
ki Coulée
eastward.

Near Pa-kow-ki Coulée the valley again holds a few trees. The Pa-kow-ki Coulée between the river and arm of the lake is wide and flat-bottomed with patches of sage brush and some good grass. From this place to the edge of the map, the Milk River valley continues wide, but is deep and forbidding in aspect, with high bare clay-banks and a few groves of trees. Thence to the point at which it finally crosses the 49th parallel, it is in some places very deep and difficult of access, but is never without well grown cottonwood trees.

Lake
Pa-kow-ki.

Pa-kow-ki is the largest lake in the district embraced by the present report. It is very irregular in shape, holds several islands, and is evidently shallow. The north-west and south-west arms are bordered by high banks, and doubtless represent old drainage channels, but the country on the north-east side is low, and as viewed from a distance presents wide areas of bare sand hills. The water is of a greyish milky colour and slightly saline.

Sweet Grass
Hills or Three
Buttes.

The following description of the Three Buttes and their vicinity is again quoted from my report on the Geology and Resources of the 49th Parallel:—The isolated mountains called by the half-breed hunters *Montagnes du Foin de Senteur*, are known to the traders of the Missouri region as the "Sweet Grass Hills." They are roughly indicated on most good maps of the west, and are there found under the geographical appellation of the "Three Buttes." As indicated by the latter name there are three distinct mountain masses. A line passing from the peak of the eastern through the central mass of the West Butte, would have a direction of about N 70° W., the central Butte lying between them, but some miles to the south. The highest summits are

those of the east apart, and rise to base. The height the aneroid barometer about an hour, is 2,746 feet above simultaneous sea level at 3,737 feet. The central Butte is 6,485 feet.

The central Butte, and around it, has been tilted up, the top at very high angles, forms quite a little with round or blue. East Butte is nearly arranged nearly as is the most prominent and connected with in height. The equal in elevation Butte was not as the others. It has as viewed from an angle of nearly 45° it is surrounded by its northern slope.

The height and the arrest of clouds and consequence much ground around the where they find a from some parts of which, on leaving the plains are rapidly a the summer season, big brook during the became quite dry much of it has been The trees are not of parts of the mountain country so treeless.

those of the eastern and western Buttes, which are about twenty miles apart, and rise nearly 3,000 feet above the level of the plains at their base. The height of the summit of the East Butte, as ascertained by the aneroid barometer, and taking the mean of two readings separated by about an hour, is 6,200 feet. That of the West Butte was found to be 2,746 feet above the dépôt camp at its base, by comparison with nearly simultaneous readings there; and taking the height of the latter locality at 3,737 feet, the height of the West Butte above the sea would be 6,483 feet.

The central masses of the Buttes are composed of eruptive trappean rock, and around them the previously horizontal beds of the plains have been tilted up, those immediately surrounding the igneous masses resting at very high angles. The West Butte is the most important, and forms quite a little mountain region, having numerous peaks and ridges, with round or blunted tops, and deep, almost precipitous, valleys. The East Butte is next in importance, and consists of four main peaks, arranged nearly as the angles of a square. The north-western of these is the most prominent and conical; the south-western is round topped and connected with the north-western by a ridge, and not far below it in height. The north-eastern and south-western summits are nearly equal in elevation, but considerably less than the others. The central Butte was not ascended, but appears to be notably smaller than the others. It has, however, an exceedingly symmetrical conical form, as viewed from almost every direction, and its slopes must form an angle of nearly 45° with the horizon. Like the East and West Buttes it is surrounded by grassy foot-hills, which are especially prominent on its northern slope.

The height and mass of the Buttes is sufficient to cause the formation and arrest of clouds in their immediate vicinity, where the rainfall is in consequence much more copious. These mountains and the broken ground around them form a favourite haunt of the buffalo [in 1874] where they find abundance of food and water. The springs arising from some parts of the Buttes are very copious, and form streams, which, on leaving the shelter of the wooded valleys and issuing on the plains are rapidly absorbed by the dry soil and atmosphere, at least in the summer season. One of these was observed to be a rapidly flowing brook during the night and morning hours, but in the afternoon became quite dry. The timber of the Buttes is chiefly pine; much of it has been burned, but it shows a tendency to renew itself. The trees are not of great size and generally in somewhat inaccessible parts of the mountains, but cannot be considered unimportant in a country so treeless. A few of the plants found at elevations above

Elevation.

Summits of the Buttes.

Streams and timber.

6,000 feet in the Rocky Mountains appear also on the summits of the Buttes.

The following paragraph, though written in 1874 and referring to conditions obtaining at that time, may also still have some interest:—

A neutral territory.

The country surrounding the Buttes is said to have been for a long time a neutral ground between various tribes of Indians. That it has been so is evidenced by the almost complete absence of buffalo bones in the neighbourhood, and the rare occurrence of the circles of stones marking camping places. The region is at present a debatable ground between the Blackfeet, Peigans, and Bloods of the west; the Sioux and Assiniboines of the east, and the Crows and other tribes of the Upper Missouri. It is not passed through save by war parties strong in numbers and travelling rapidly. Ten miles north of the Middle Butte the bodies of over twenty Crow Indians were found, unburied, on the scene of a conflict.

PLAINS BETWEEN MILK RIVER AND BELLY RIVER.

Decreased elevation to the north.

Plateaus and hilly tracts.

Beyond the region of plateau and high plain which borders Milk River valley on the north, the whole surface of the country slopes gradually northward toward the Belly River, till, between Coal Banks and the Chin the elevation is about 3,000 feet, and between Seven Persons River and the South Saskatchewan about 2,500 feet only. It must not be supposed, however, that the surface is quite uniform. Besides the valleys of some important coulees, several low plateaus appear, of which the Chin, and that midway between Seven Persons River and the Saskatchewan are most important. The Bull's Head constitutes the most prominent portion of a still more elevated plateau at the extreme east of the map known as the Peace Buttes. Ten miles south-east of Coal Banks a limited tract, characterised by irregular low hills, is crossed on the MacLeod-Benton trail. The region south of the Belly, between Drift-wood Bend and its mouth, is rolling or rather hilly, with intervening pools and lakes. Some small sand-hills also occur immediately south of the confluence of the Bow and Belly. South of the crossing of Seven Persons River by the Cypress trail, is another broken hilly tract, apparently composed of drift materials, and strewn with numerous boulders. To the south of this is a valley three miles wide, not resembling that of a river or related to that of any existing stream. The bottom slopes gently southward, but the main course of the valley is nearly east and west. This is again bordered to the south by a well marked hilly ridge, which separates it from the Lake Pā-kow-kī valley, and is also about three miles wide.

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The Chin Coulée is the most remarkable of the valleys traversing this part of the plain, and from the Chin to its junction with Peigan Creek at the eastern crossing of the Cypress trail, has a length of nearly seventy miles. It is a trough-like valley from half a mile to a mile in width, and depressed from 150 to 250 feet below the prairie level. A number of small lakes lie in the valley and are connected by a little flowing water at seasons of flood, but during the summer some of them dry up completely. Boulders are quite abundant in some places, having been concentrated by the removal of the finer portion of the drift deposits, and the underlying Cretaceous rocks are exposed in a number of places in its banks. On the south side a little scrub occurs, and in the bottoms occasional thickets of sage brush. The Forty-mile Coulée which joins it from the northwest is similar in character, but both this and the upper part of the Chin Coulée appear to die out entirely before reaching the bank of the Belly River.

The Peigan Creek above alluded to, is really the upper part of the Seven Persons River. Its valley is narrow and evidently of more recent origin than the Chin Coulée, and when the stream reaches the latter, it immediately adopts it, and flows in it to the South Saskatchewan River. The valley of the Seven Persons River, north of the Cypress trail, therefore, constitutes the continuation of Chin Coulée, and is wide and important. It holds, at least in its upper part, a few small trees.

South of the Chin Coulée is a second and very similar valley, which runs in a nearly parallel direction at a distance of from six to eleven miles, and may be denoted by its Blackfoot name Etzi-kom. This valley also holds several small lakes, and at its eastern end contains a small stream which flows into the north-west arm of Lake Pā-kow-kī. The coulée originates in the region east of the Fifteen-mile Butte on the MacLeod-Benton trail. Kipp's, Middle, and Ed. Mahan's Coulées—crossed south of this point by the same trail—were, by the exploration of 1883, found to be branches of Verdigris Coulée, the mouth of which has already been referred to in connection with the description of Milk River. There are in all seven lakes in Verdigris Coulée east of the MacLeod-Benton trail. Of these the largest is about seven miles in length. This coulée in its steep banks and flat bottom resembles those above described, and like them cannot be accounted for by the present conditions. Not only do the small streams now flowing into it lose themselves in its lakes so completely that not even a permanent flood-channel connects the lakes in its upper part, but its bed is almost absolutely flat from the trail-crossing of its upper branches to its mouth on the Milk River.

As a grazing country, the region of plains between Milk River and the Belly may be described generally as of fair quality. It varies from

indifferent, to fair and good, and may be classed as very good in a few limited tracts. The best and most extensive areas of grazing land are found in the vicinity of the MacLeod-Benton trail and westward, including the Milk River Ridge region; between Cherry Coulee and the Seven Persons River north of the Cypress trail; south of the Cypress Trail near the 111th meridian; and west of Lake Pa-kow-ki, in the angle between it and the Milk River.

Cairns

The cairn on the south side of the Saskatchewan near the confluence of the Bow and Belly is regarded with much veneration by the Indians, who call it O-max-ökotok, but I have been unable to discover any reasonable explanation of its origin or meaning. It is a pile of rough boulders about six feet in height, with a breadth of base of about fifteen feet, and occupies a commanding situation on the brow of the hill overlooking the river. A few other small cairns occur in this district, but are probably only landmarks. Ten miles south of the Cypress trail on the 111th meridian, and in a few other places, some old stone-piles, now nearly imbedded in the sod, appear to cover shallow graves. In the Etzi-kom Coulee, a couple of miles from Lake Pa-kow-ki, a cairn, apparently of pretty recent date, probably marks the scene of a fight, as some rough low breastworks of boulders were also noticed there.

THE ST. MARY, UPPER BELLY, AND WATERTON RIVERS AND COUNTRY
IN THEIR VICINITY.

St. Mary River.

The valley of the St. Mary River may be characterized generally as narrow, and the river is extremely tortuous both in its main direction and on a smaller scale within the limits of the valley. Its length from the 49th parallel to its mouth, measured in five mile stretches, is about fifty-seven miles. It rises in a large lake in the mountains south of the 49th parallel, and for some distance after crossing the line continues clear and blue. It is extremely rapid, falling about 1,100 feet from a point five miles north of the 49th parallel to its mouth, or at a rate of twenty-one feet to the mile—its course being again measured in five miles stretches without regard to its minor flexures. It was not without much trouble and some danger that we descended it in a small canvas boat in the summer of 1881, and at the low water stage it would be nearly if not quite impossible to do so.

Character of
the valley.

For the first ten miles below the point above indicated, it may be described as almost a continuous rapid, and is filled with innumerable flat islands, some of which are lightly wooded. Five miles north of the 49th parallel, a large cultivable flat occurs on the east bank, and for about twelve miles, or to the mouth of Lee's Creek, the valley is moderately wide, attaining in some places a width of a

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mile. From the point above indicated, it cannot be said how many miles below Lee's Creek are a few more miles with this exception to the trail. At a point about ten miles to the north, and in the angle between the banks nearly continuous, and a fall a few feet on the west bank, is a rapid, and is filled by the river, the two sides of the valley. The present aspect of the valley is that it has an age-old feature is particularly noticeable in the trough of the Upper Belly. The pasturage of the foot-hill between the river and the country is entered by the mouth of the river.

Though the St. Mary River is the Upper Belly or Waterton River, more important than the 49th parallel, it averages a little less than a mile. It is generally suitable for farming, and crossing of the river to the mouth, it averages seldom scarped south of the 49th parallel, 4,728 feet, and falls (measured as before) below the level of the MacLeod trail-crossing.

The Waterton River, at its confluence with the Upper Belly, is a descent in that direction to the Upper Belly, included between the Waterton Lake (called Kootanie Lake

mile. From the flat above alluded to, however, to its mouth, it cannot be said to hold any land of a cultivable character. Two miles below Lee's Creek the scattered trees come to an end. There are a few more in sheltered situations in the Gooseberry Cañon but with this exception it is treeless to near the crossing of the MacLeod trail. At a point five miles below Lee's Creek, the river turns abruptly to the north, and for about five miles flows through a cañon with scarped banks nearly continuous. This has been called the Gooseberry Cañon, and a fall a few feet in height occurs near its lower end. Below the fall, on the west bank, a remarkable horse-shoe shaped valley, formerly occupied by the river, occurs; but the narrow rocky tongue which separated the two sides of the bend having since been cut through, it is now dry. The present aspect of the St. Mary River valley is such as to indicate that it has an age less than that of most others in the district, and this feature is particularly marked when it is compared with the parallel trough of the Upper Belly River.

Recent origin of valley.

The pasturage on the prairies and rolling hills—constituting the edge of the foot-hill belt—about the upper part of its course, may be classed as very fine, and to the Gooseberry Cañon as good. Thence a drier country is entered, but the grass on the surrounding prairies to the mouth of the river, is generally good, and always fair.

Pasturage.

Though the St. Mary River carries much more water than either the Upper Belly or Waterton, the valley of the Upper Belly is larger and more important than that of either of the others. From the vicinity of the 49th parallel northward to the MacLeod trail-crossing, it probably averages a little less than a mile in width, and is seldom less than half a mile. It is generally more or less wooded, and presents numerous bottoms suitable for farming, some of which near the confluence of the Waterton and crossing of the trail are already occupied. Below the trail-crossing, to the mouth, it averages about a mile and a half in width, and the banks are seldom scarped. The Upper Belly rises in lakes in the mountains south of the 49th parallel, which it crosses at an elevation of about 4,728 feet, and falls about 1,800 feet in its course of sixty-five miles (measured as before in five mile lengths) to its mouth. Near the MacLeod trail-crossing the valley is depressed about one hundred feet below the level of the prairie.

Upper Belly River.

The Waterton River, from its source in the lake of the same name to its confluence with the Upper Belly, is forty miles in length, and has a descent in that distance of nearly 1,000 feet. It flows nearly parallel to the Upper Belly, and a narrow belt of foot-hill and prairie country is included between the two streams.

Waterton River.

Waterton Lake (or Chief Mountain Lake, sometimes also erroneously called Kootanie Lake) is nine and a half miles in total length. The

Waterton Lake.

bearing of the upper portion, seven miles long, is nearly north and south. It lies between grand and rugged mountains, and constitutes without doubt the most picturesque locality in the whole district. The lower part of the lake, two and a half miles long, is nearly separated from the last by a constriction formed by a rocky spur from the east side, and turns abruptly to the east. A short stream connects this with a second lake, which lies entirely in the foot-hills, is three miles in length, and gives issue to the Waterton River.

Waterton
River valley.

The valley of the river averages about half a mile in width, and contains more or less timber along nearly its whole length. Scarped banks are of frequent occurrence, but they are generally low, though cliffs about one hundred feet in height occurs at one point six miles below the mouth of the Drywood Fork. The valley, however, offers little land suited for cultivation. Three tributaries join the river from the west. The first a large brook, two miles below the lake, and further down the North Fork and Drywood Fork. The latter is the most considerable, and the lower part of its valley is nearly as large as that of the Waterton.

Name of the
river.

The Waterton River has appeared under this name on the map for about twenty-five years, but of late some confusion has arisen, owing to the circumstance that settlers recently entering the country have re-named it the Kootanie, and that this name has even appeared on some maps. There is nothing to be said in favour of this change, and the fact that another and much larger river on the west side of the range has long been known by the latter name, renders its introduction here particularly inconvenient and misleading. Nothing but complete ignorance of the earlier geographical work in the district, can excuse the perpetuation of this name as applied to the stream and lake now described.

Country in the
vicinity of
these rivers.

The general character of the country about the Upper Belly and Waterton Rivers requires but a few words of description. A great part of it belongs to the foot-hill belt already characterized, and yields everywhere magnificent bunch-grass pasturage. Near the confluence of the two rivers the grass is somewhat shorter, but still very good. Below this point, on both sides of the Upper Belly, the grass may be described as generally fair to good, though considerable tracts which must be classed as indifferent, also occur. The Belly Butte, with its scarped and furrowed western front, is a prominent object near the confluence of the two streams. The Little Rocky Ridge, a few miles south of the mouth of the Drywood, between the two rivers, is another rather noticeable landmark. South of this the most marked feature in the foot-hills—particularly to the east of the Upper Belly and near the head of Lee's Creek—is the remarkable parallelism of the

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sandstone ridges, which often run for miles, scarcely varying more than a degree or two in their general direction. Near the upper part of the river, there are also some areas completely dotted with almost innumerable small lakes and pools.

THE OLD MAN AND BELLY RIVERS.

The Old Man and Belly Rivers, with the upper part of the South Saskatchewan, occupy the centre of a wide depressed area, which runs across the entire district with a course a few degrees north of east. This important feature originates at the mountains precisely opposite the remarkable gap in the Palaeozoic rocks of the outer ranges, and both are doubtless due to some general structural circumstance not yet clearly ascertained.

The streams which unite west of the central axis of the Porcupine Hills, to form the Old Man, originate in the mountains; some of them far back in the range, and most of them, in common with the other streams of the district, flow nearly at right angles across the foot-hill belt. The more important of these streams are as follows, in order from south to north:—Pincher Creek, Mill Creek, South Fork, Middle Fork or Crow Nest River and North Fork. Pincher Creek issues from the base of the mountains as a rapid stream twenty-five feet wide, which is not subject to heavy floods as it does not rise far back in the range. It flows north-eastward five miles, passing between the ends of two remarkable, high, wooded ridges, and then nearly north for about ten miles, before resuming its eastward direction. At the crossing of the road near the Police Farm, it is a stream sixty feet wide and generally rapid and shallow. Mill Creek flows northward, and rises far back in the mountains south of the gap in the Palaeozoic before referred to. For five miles from the point at which it leaves the Palaeozoic rocks, the country about it is very rough and wooded. Thence for three and a half miles, to its mouth, it is bordered by wide terrace-flats and more gentle slopes covered with fine grass, which rise at a short distance to wooded hills. It is a larger and more rapid stream than the last. The South Fork of the Old Man issues through the above-mentioned gap in the Palaeozoic mountains, and in its main direction flows nearly eastward, receiving Mill Creek and then uniting with Pincher Creek. It is much larger than either of these. The Middle Fork, about equal in size to the last described, may be said to rise in the Crow Nest Lake, in the pass of the same name, with an elevation of 4,426 feet; and where it crosses the eastern base of the old rocks it has an elevation of 4,170 feet. It also flows nearly due east, in a wide valley, at first bordered by high wooded

Remarkable depression.

Tributaries of Old Man River.

Pincher Creek.

Mill Creek.

South Fork.

Middle Fork.

North Fork.

foot-hills, but before joining the North Fork passes into a prairie country. The North Fork, fed by numerous streams which have their sources in the main watershed, issues from the mountains through a narrow gorge at a height of 4,437 feet, and is more important than any of the other tributaries of the Old Man. For thirteen miles it flows south-eastward, crossing the foot-hill ridges, which are here very distinct and prominent, somewhat obliquely, and falling in the above distance about 350 feet. Its main valley through the foot-hills is wide, but the stream itself is almost everywhere bordered by low rocky cliffs affording a fine section. From the direction indicated, it turns abruptly southward, and flows in a wide well grassed and partly wooded valley, parallel to the base of the Porcupine Hills, thirteen miles further, to its junction with the Middle Fork.

Country about
branches of
Old Man River.

The part of the foot-hill belt through which the upper branches of the Old Man flow, is for some miles along the base of the mountains pretty densely wooded, with only occasional prairie valleys, and the higher ridges continue to bear a few trees throughout. Wherever it is open, however, it presents a magnificent growth of bunch-grass and constitutes a remarkably fine grazing region. In the valleys of some of the streams, and in their vicinity, there are considerable tracts of land which may be cultivated, though no exact estimate of the extent of these can be given, owing to the uncertainty still existing as to the height in different localities at which frosts become too severe. The most important of these is, however, doubtless that on which the Police and Government Indian farms are situated. This is a tract about three miles in width, which runs south-eastward from Pincher Creek toward the Waterton River, and is based on the outcrop of a series of soft rocks.

Old Man River
west of Fort
MacLeod

The valley just referred to, with that in which the lower part of the North Fork of the Old Man flows, limits the Porcupine Hills to the west. To the eastward, the Old Man River, occupying the centre of a depressed area nearly ten miles wide, flows through these hills to Fort MacLeod. The hills to the north are here wooded at the summit, but the southern detached portion bears no trees. The banks of the river are fringed with timber, and some fine bottoms occur. Before reaching Fort MacLeod the bunch-grass has entirely given place to the shorter buffalo-grass.

From Fort Mac-
Leod eastward.

From Fort MacLeod to the confluence of the Upper Belly, at which point the Belly River proper may be said to begin, and thence to Coal Banks, the course of the river is circuitous. The hard sandstones of the St. Mary River subdivision, and the shales of the Pierre, appear to have offered two lines of considerable resistance to the stream, the first of which has been overcome by a northern, the second by a southern flexure. The distance by the river from Fort MacLeod to Coal Banks,



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OLD MAN RIVER.

Looking Southwest from North Bend, nine miles below Fort MacLeod. Rocks of St. Mary River Subdivision, Ladang.
Porcupine Hills in the distance.

G. M. D. Photo. Jan. 1914.
Geological Survey.

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measured in two mile lengths, is thirty-six miles, the relative elevations being 3,096 and 2,732 feet respectively, giving a fall of about ten feet to a mile. The river is consequently rapid, and being encumbered with boulders in many places is only navigable for boats during high water in early summer. The banks vary from fifty to one hundred and fifty feet in height, and are often well grassed, though generally scarped and cliff-like at the convex bends. Some fine bottoms for farming occur, particularly near the mouths of the Upper Belly and St. Mary Rivers, and the river is more or less fringed with trees and bushes throughout this part of its course. The reach of the valley which turns south from the great bend north-east of MacLeod, is for some miles continuously narrow, with low rocky banks and cliffs and no bottom-lands. Below the St. Mary, the south bank is high and weathered into rugged bad land forms, and just above Coal Banks several large wooded islands occur. Fort Kipp, one of the old trading posts, but now entirely destroyed, was situated at the confluence of the Upper Belly. Fort Whoop-up, still in good preservation, is at the mouth of the St. Mary.

At Coal Banks ferry, the high water channel of the river is 437 feet wide. From this point it runs northward for twelve miles to Big Island Bend. The prairie level is 300 feet above the river, and scarped banks occur, with fine sections, occasionally over 200 feet high. The valley is of the usual trough-like form, about a mile in average width in the bottom, with the river meandering from side to side and still evidently actively engaged in widening the trough by the constant waste of the cliffs at its convex bends. The flats are generally covered with fine cottonwood and luxuriant foliage, in which the choke-cherry bushes are prominent, and several of the bottoms are adapted to agriculture.

On turning eastward the valley becomes somewhat more confined, and is still nearly as deep as before, but with the banks more gently sloping and grassy, and fewer good sections, to the mouth of the Little Bow. From its first bend below Big Island to within a mile and a half of the Little Bow, there are no trees. The country evidently becomes dryer in this direction, and the low cactus abounds on southward-facing banks. About the mouth of the Little Bow are wide bottoms with some timber and probably a thousand acres of cultivable land.

From the Little Bow to the mouth of the Belly, there are practically no trees or shrubs, with the exception of those on a few islands. The bottom of the valley averages scarcely more than half a mile in width, and the banks are from one hundred to one hundred and fifty feet in height. They are often for considerable distances grass-grown, and the sections of the rocks are not nearly so good as before. Wolf Island, nine

Fall of the river.

Banks and bottom-lands.

Coal Banks to Big Island.

Big Island to Little Bow.

From Little Bow eastward.

miles above the mouth of the river, is the largest in this part of its course, being half a mile long. It supports some cottonwoods on its lower end.

A mile and a half from the mouth of the river is a flat with a grove of cottonwood and thickets of large *Artemisia* bushes. Opposite this point the river is 720 feet wide, with a velocity of 3.6 miles per hour, being here rather less swift than in most places on its lower course.

Fall of the
river

The height at the confluence of the Belly and Bow is 2,212 feet, giving a difference from Coal Banks of 520 feet. The distance, measured in two mile stretches, is seventy-six miles, and the average slope is at the rate of 6.8 feet in a mile, though considerably more in the upper part and less in the lower. In the autumn the volume of the river is much decreased, and it would not be easy to descend some parts of it in a large flat-bottomed boat. During high-water, in the early summer, it would probably be possible to make a few trips with a small stern-wheel steamer, as far up as Coal Banks, but it cannot be counted on as a means of carrying eastward any large quantity of coal from the fine seams in that vicinity.

South Saskat-
chewan River.

In 1881 no sign of habitation existed below Mr. Sheran's house at Coal Banks, and in descending the river we saw but a single Indian.

The island at the confluence of the Belly and Bow supports a few cottonwood trees, but from this point to the edge of the map, wood is extremely scarce along its course. Between the confluence and Cherry Coulee, high, scarped, desolate banks occur on both sides of the South Saskatchewan, and the general level of the prairie is nearly 250 feet above the river at the latter point. At the same place the width of the stream was found to be 1,013 feet, and the current three miles an hour only. This river is generally tranquil to Medicine Hat at the eastern border of the accompanying map, but the valley is narrow, and in places almost cañon-like with banks 250 to 300 feet high.

PLAINS BETWEEN THE BELLY AND BOW RIVERS.

Western
portion.

Bounded by the Belly and Bow Rivers to the south and north, and between the edge of the Porcupine Hills to the west, the Snake Valley and lower part of the Little Bow to the east, is a region about forty miles in width by sixty-five in length, which is drained by Willow Creek, the upper part of the Little Bow and a few small streams running into the Bow. The tributaries joining these streams in this region are, however, small and few, and it is evidently one of comparatively limited rainfall and from which the surplus moisture is for the most part removed by evaporation. Its western portion, lying along the base of the Porcupine Hills, is a lightly undulating or almost level

General
character.

plain with an average elevation of about 300 feet. Its character and position are similar to Spring Ridge, the rise from 300 to 400 feet to Calgary, north of the level course.

One branch of the river, while the two others flow through the pine Hills and the prairie, is an insignificant stream, tortuous with small rapids, level of the prairie near and in the valley of its course.

Masquito Creek is a sluggish stream, showing no rock, and a smaller stream joins it.

The Little Bow River, at a short distance to the west of the wood River, with a current of 3 miles per hour, even above the mouth of the Bow, even above the mouth of the Bow, and one hundred feet wide, is of greater width than the Little Bow River. The Little Bow River, at the mouth of the Belly River, is a bottomed valley, the course in it. The

The Highwood River, with mountains, carries a heavy load with stony bed. The Highwood River, at the mouth of the Belly River, is a bottomed valley, the course in it. The

It appears very different from the former period following the glacial period.

While the greater part of the

plain with an average breadth of over twenty-five miles, and a mean elevation of about 3,300 feet. Its eastern part is much more broken in character and largely composed of plateaus, which include the Black Spring Ridge, the Thigh Hills and Buffalo Hills, of which the summits rise from 300 to over 500 feet above the plain. The trail from MacLeod to Calgary, north of the 50th parallel closely follows the western edge of the level country.

One branch of Willow Creek rises in the mountains in latitude $50^{\circ} 7'$, ^{Willow Creek.} while the two other main branches derive their water from the Porepine Hills and foot-hills behind them. It is, except at seasons of flood, an insignificant stream, and in the lower part of its course is extremely tortuous with small sharp bends, and not much depressed below the level of the prairie. Trees occur along the borders of its tributaries near and in the Porepine Hills, but are very scarce on the lower part of its course.

Musquito Creek, where it crosses the Calgary trail, is a small, rather ^{Musquito Creek.} sluggish stream, full of water-weeds, and flows in a wide shallow valley showing no rock. It is joined near the trail by Spring Creek, a smaller stream also derived from the edges of the Porepine Hills.

The Little Bow does not cross the Calgary trail, but rises in springs a ^{Little Bow.} short distance to the east of it, and quite close to the bank of the Highwood River, with no intervening high land. The valley of the Little Bow, even above the confluence of Musquito Creek, is about a mile wide and one hundred feet deep, while the stream, where rapid, is ten to fifteen feet wide only, but frequently forms long sluggish pools of greater width. At its mouth, Musquito Creek is considerably larger than the Little Bow, but flows in a valley comparatively small. Thence to the Belly River, the Little Bow continues to occupy a large flat-bottomed valley of similar character, and pursues a very tortuous course in it. There is no wood whatever in the Little Bow Valley.

The Highwood or High River, rising from several branches in the ^{Highwood River.} mountains, carries a considerable volume of water and is a rapid stream with stony bed. Where it crosses the Calgary trail it is nearly one hundred and fifty feet wide, and the level of the country is but little raised above it for a considerable distance on each side, but particularly to the north. Its tributary Sheep Creek, is a smaller stream, similar in ^{Sheep Creek.} origin and character, but its valley where crossed by the trail is narrow. The Highwood is thickly wooded eastward to the trail-crossing, and Sheep Creek for some distance further east. Some groves again occur near the mouth of the Highwood on the Bow.

It appears very probable that the waters of the Highwood have at a former period followed the Little Bow Valley to the Belly.

While the greater part of the tract above defined, between the Pore-

Grazing lands. pines, the Snake Valley and lower part of the Little Bow, belongs strictly to the buffalo-grass country, its western border blends with the bunch-grass district, and this character even extends over a portion of its north-western corner. The pasturage may be characterized as generally good, and though in some places indifferent, it can seldom be classed as poor, while extensive areas are very good. The country is also pretty well supplied with water, in pools and swamps, many of which last throughout the summer. It may therefore be described as an excellent grazing region, and will doubtless before long be fully utilized in this way. The grass on the plateaus of its eastern part, is generally good, though according to Mr. J. C. Nelson's description, the 'Thigh Hills include a considerable area of land with dry, hard clay hills and indifferent grass. Boulders are very abundant in a few localities where the surface has been considerably lowered by denudation, particularly near the valleys of streams.

Cultivable area. The western, or more level portion of the tract now under description, differs considerably in the character of its soil from any other area of similar extent included in the present report, being very frequently covered with several inches, and occasionally by a considerable depth of dark mould or sandy loam, which overlies the pale grey or yellowish loamy or clayey soil more usually found. On account of its comparatively low elevation and not exceedingly dry climate, it is probable that a considerable area along the eastern base of the Porcupines may eventually be cultivated. In the vicinity of Willow Creek, north of Fort MacLeod, the prairie averages about 200 feet above the water of the Old Man River, and much of it possesses a good soil. Several farms are already established along the Highwood River, and there is every prospect of this settlement growing to considerable proportions.

Sun-dial Hill. A point of note to the Indians in this region, is that called Sun-dial Hill by Mr. Nelson. There is here a cairn with concentric circles of stones and radiating lines. I have not seen it, and therefore cannot describe it in detail. It is named *Onoka-katzi*, and regarded with much reverence.

Snake Valley. The Snake Valley appears, like that of the Little Bow, to have carried at some former period a considerable volume of water, but now contains marshes and shallow lakes only, most of which dry up in the autumn. It is throughout below the 3000-foot contour, and its banks show occasional low exposures of the clays and sandstones of the Laramie. An extensive tract of rolling hills and plateaus lying east of it, is known as the Rocky Buttes, and many parts of it afford very fair pasturage, though boulders and smaller stones are scattered thickly over some portions. The elevation is often considerably over 3,000 feet, but has

Rocky Buttes.

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The southern portion of the tract west of the Little Bow and between it and the Bow, is a level or lightly undulating plain of a very arid character, with a general elevation of about 2,600 feet, and clayey or sandy soil. The southern portion of the Rocky Buttes extends in the form of a gently swelling rise even to the Belly River. It rises with a long light slope from the Driftwood Bend of the Belly to a height of about 2,800 feet, and then falls rapidly westward to the valley of the Little Bow. A wide shallow valley runs north and south between the Bow and Belly thirteen miles east of their confluence, and like most of the depressed areas evidently caused by denudation, is thickly boulder-strewn. The grass on these plains is generally very short, and must be classed as fair to poor, and in places very poor. In the latter part of the summer, water is extremely scarce and as a grazing region this is of comparatively small value.

Angle between
Bow and Belly.

THE BOW RIVER.

The Bow is the most important river of the entire district, and might I believe be navigated by light stern-wheel steamers to the Blackfoot Crossing, though the vicinity of the Canadian Pacific Railway to its north bank will prevent its extensive use as a channel of communication. The Bow rises in the heart of the Rocky Mountains, about latitude $51^{\circ} 40'$, and flows between high Paleozoic ranges for many miles in a general south-eastward direction, after which it turns abruptly to the eastward and cutting across the last of these ranges nearly at right angles issues through the "Gap" on the region of the great plains, with an elevation of 4,100 feet. It is already at this point a noble stream, with clear, blue and sparkling water and a rapid current. The unsullied character of this and the other streams flowing from the mountains in the district here described, would alone be evidence of the absence of true glaciers of any size in those parts of the range supplying their waters, and though numerous snow-fields of varying dimensions appear about the higher peaks, true glaciers seem to be almost or altogether absent to the east of the watershed. In common with the other rivers, the Bow after leaving the mountains soon becomes charged with suspended matter, by the wear of the soft formations forming its banks, which are constantly being brought under its action by slides, and in seasons of high flood the river becomes muddy nearer to its exit from the mountains than at low water.

Sources of the
Bow.

Clear water of
its upper
reaches.

For three miles from the Gap the banks of the Bow are quite low and the sandstone and shale rocks, here filling a bay in the edge of the

The Gap to
Morley.

Palaeozoic, lie at very moderate angles. It may be forded here at several places, at low water. At this point the Kananaskis or Swift River, also from the mountains, joins it from the south, and the rocks assume the flexed and disturbed aspect characteristic of the foot-hill region. Immediately below the mouth of the Kananaskis, the Bow forms a fine fall of which the vertical portion is about twenty-five feet in height, constituting the best and most available water-power in the entire district. The fall occurs over hard sandstone beds, which dip up stream, and the river immediately below is bordered by high, nearly perpendicular banks of dark Cretaceous shales. Thence to Morley—a flourishing little settlement originated as a Wesleyan mission—the river is extremely rapid and rocky, and flows between high banks, which often become almost vertical.

Bow Valley in
the Foot-hills.

The valley of which this part of the Bow occupies the axis, is wider and more important than that of any other stream traversing the foot-hills, and between the river and bases of the hills there are wide stretches of terrace or bench land, through which portions of moraine ridges, evidently formed in connection with a previous large glacier from the mountains, occasionally project. The soil of these terraces is unfortunately often sandy or gravelly, and the region is rather liable to summer frosts from its height and proximity to the mountains. The bordering hills are high and broad, with comparatively narrow intervening valleys, and do not precisely resemble the long parallel ridges elsewhere more usual along the base of the mountains. These on the south side are pretty densely wooded, and most of the country for some distance to the south of them partakes of the same character. On the north, the hills are much less uniformly wooded and separated by wider valleys, and in the aggregate there is a large area of fine grazing land.

In 1881 I descended the Bow River from Morley to its mouth in a canvas boat for the purpose of carefully examining the rock sections in its banks. The description of its geological features is elsewhere given in detail, and in this portion of the report it is proposed to give merely some general notes on the character of the river, its valley and the country bordering it.

Morley to
Calgary.

Eight miles below Morley, the Ghost or Deadman River joins the Bow. This is usually a small stream, but near the mountains has a gravelly bed about a quarter of a mile wide, and evidently carries a great quantity of water at some seasons. Near its mouth is situated the worst rapid which occurs on the Bow between Morley and Calgary. Six miles lower, a brook known as Coal Creek flows in, also from the north, and at this point the foot-hills may be said to come to an end, and are replaced by high, nearly level plateaus of irregular



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BOW RIVER ABOVE MORLEY, LOOKING WEST

Artists—G. R. Debnick & Co., Montreal.

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outline, which must be regarded as forming the northern continuation of the Porcupine Hill region. The Jumping Pound, a stream of considerable size, which rises in the foot-hills to the south, flows in three miles below Coal Creek. Thence to Calgary the river receives no tributaries of importance.

Throughout this part of its course, the banks of the river and some of the flats are frequently well wooded, and there are also many wooded islands. The bordering plateaus are everywhere covered with luxuriant bunch-grass.

The total distance by the river from the Gap to Calgary—measured in two-mile stretches—is fifty-four miles, and the rate of fall, deducting twenty-five feet for the waterfall above described, is fifteen feet to the mile.

The situation of Calgary is remarkably beautiful. The plateaus here retire to some distance from the river, which is bordered by wide flats thickly covered with bunch-grass, and well adapted to agriculture. The river is fringed with trees, and from the higher points in the neighborhood the Rocky Mountains are still visible. The Elbow River, which here reaches the Bow, has flowed parallel with it a few miles to the south for some distance. It also rises in the mountains, but on leaving the foot-hills,—which on its upper course, are wooded and rough—its valley is wide, with long light slopes on either side, and almost without the high scarped banks which characterize the Bow in the same part of its course. The hills to the south of the Elbow are all more or less densely wooded, but the slopes to the north bear a fine growth of bunch-grass, and the whole valley is very attractive in appearance. A considerable quantity of timber has already been cut and floated down the Elbow to Calgary, and small rafts have also been run down the Bow River from the vicinity of Morley. The elevation of the Bow at Calgary is 3,366 feet.

Separated from the lower reach of the Elbow by a very narrow strip of high land, and parallel to its course and that of the Bow below Calgary, is another of the remarkable old trough-like valleys which indicate former river action.

For fourteen and a half miles below Calgary, the Bow flows nearly due south on the 114th meridian, after which it turns eastward eight miles to its confluence with the Highwood. The banks are generally about one hundred feet in height along the river, and though sometimes scarped, often bear groves of cottonwood. The bottoms are not usually large, but are sometimes well adapted to farming, and the country generally, is very well grassed.

The so-called Pine Cañon extends for about nine miles below the mouth of the Elbow. The immediate banks of the river are here

Pine Canon
Blackfoot
Crossing.

almost 200 feet in height. They are steep and generally scarped, but in the hollows well wooded with a mixture of spruce and broad-leaved trees. This is the furthest eastward occurrence of coniferous trees on the Bow. From this point the valley again widens, and the banks are scarped only at the convex bends of the river. They are at first much lower, often from fifty to sixty feet only, but on approaching the Blackfoot Crossing, gradually rise and attain a height of from one hundred to one hundred and fifty feet. The greater part of this stretch of river is moderately direct in its course, but before reaching the Crossing it makes several great bends and a great number of minor flexures. The stream is often wide and shallow with innumerable sloughs and channels, and in two parts of its course—twelve and two miles respectively above the Crossing—forms a complete plexus of islands and shoals. These appear to have been produced by the action of the river on great landslides from its banks. This part of the valley may be described as well supplied with timber on flats and islands throughout, and there are some fine cultivable bottoms. The width of the valley is irregular, but probably averages three quarters of a mile between the abrupt slopes. The country above is well covered with fine buffalo-grass, but evidence of increasing dryness of climate is found on approaching the Crossing. The soil also becomes sandy in many places near the Crossing, and areas of sand-hills occur on the plains in the vicinity of the river near that place.

Fall of the
river
Rapids.

The elevation of the Bow at the Blackfoot Crossing is approximately 2,575 feet, as compared with 3,366 feet at Calgary. The distance by the river eighty miles, and the resulting fall 976 feet to the mile. The worst rapids occur in a reach of a few miles in length below the mouth of Fish Creek, and are both rough and strong. The swiftness of the current, together with the numerous shallow bars and boulders, render this part of the river unsuited for steamboat navigation.

Blackfoot
Crossing.

About the Blackfoot Crossing are wide flats partly wooded and adapted to agriculture. This point has, however, attained its importance as being from time immemorial a place of resort to the Indians, partly, no doubt, on account of the existence here of a good ford.

Old fortified
camp.

On the north bank of the river near the Crossing, are the remains of a fortified camp, which is attributed to the Indians, and doubtless correctly so, but does not bear marks of any great antiquity. It is a shallow trench of semicircular outline, four hundred feet in greatest diameter, with ten well-defined hollows along its inner margin, which have been shelter pits. The unfortified side is formed by the descending slope of the edge of a low terrace, and the included area is naturally broken.

From the Crossing to Horse-shoe Bend, the valley averages about

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three quarters of a mile in width of bottom, and continues generally well fringed with wood. The banks are everywhere over one hundred feet in height and frequently show high scarps, which are principally of boulder-clay. Two important abandoned channels are observed, one on the south side, a few miles below the Crossing, evidently dating from a remote period.

Islands continue numerous to the point now reached, but beyond Horse-shoe Bend are seldom met with. The total number of islands—small and large—noted from Morley to Horse-shoe Bend is two hundred and thirty-five. This enumeration is of course only approximately correct, owing to the difficulty in some cases of deciding, while rapidly descending the stream, which portions of the low ground are actually surrounded by water, but may serve to give some idea of their frequency.

At Horse-shoe Bend, are some rather remarkable bare bad-land hills. From this point to Grassy Island the width of the bottom of the valley averages about half a mile, and the banks rising immediately from the river or at a little distance back from it, are generally about one hundred and fifty feet high. There are but four small islands, and the banks are generally barren and desolate in appearance, being composed of dark Cretaceous clay-shales of the Pierre group, with little covering of drift material. The plains above bear short buffalo-grass and would yield but indifferent pasture, and the low-growing cactus begins to abound on stony and sandy tracts. This part of the valley is absolutely treeless and the whole region is evidently very arid.

Grassy Island—one mile in length—is notable only as marking the position of the outcrop of an important coal seam. Thence for about twenty miles the valley is of a markedly different character. The banks near the river probably average fifty feet in height only, and the country does not reach an elevation of one hundred feet for some distance away from it. There are scarcely any true flats, but light long slopes extend in most places almost from the water's edge. There are still no trees or bushes anywhere to be seen, but the plains are covered with a somewhat better growth of buffalo-grass.

At the point now reached, south of the Little Rolling Hills, the river cuts through a higher tract which is evidently in connection with the occurrence of these hills. The banks become one hundred feet high, and on the south side are broken and deeply scored by ravines, while the country rises to hills 200 feet in height at a short distance. About ten miles below this place, bad-land banks from one hundred to one hundred and fifty feet high again occur, and in the intervening reach the banks are seldom less than eighty feet in height. Narrow flats here again appear, but the valley does not average half a mile in width

Blackfoot
Crossing to
Horse-shoe
Bend.

Islands.

Horse-shoe
Bend to Grassy
Island.

River below
Grassy Island

Little Rolling
Hills.

of bottom. Near this place the river turns abruptly to the south, and continues to flow between banks about one hundred and fifty feet high to its junction with the Belly, while its valley averages half a mile in width, the scarps generally showing boulder-clay.

Fall of the river.

Navigability

The total distance from Blackfoot Crossing to the mouth of the Bow, by the river—measured as before in two mile lengths—is 103 miles. The elevation at the latter point is 2,212 feet, and the average slope of the river 3.53 feet to the mile. This fall is pretty uniformly distributed throughout, and three feet of water was found in September, 1881, on all the bars, so that it may be considered navigable for light stern-wheel steamers from the Crossing down. A few large boulders occur in the channel, and at one point, thirteen miles north of the confluence, a number of large sandstone blocks were observed to interrupt its course, but it is probable that even these would not offer any serious impediment to the passage of a steamer. The width of the river, determined at a point four miles below the Blackfoot Crossing, is 573 feet, at a point ten miles below Grassy Island, 560 feet, and it averages probably 500 feet throughout this part of its course.

Treeless character of lower valley.

With the exception of two islands, within ten miles of the confluence, on which a few cottonwood trees have formerly grown, the valley is quite treeless from Horse-shoe Bend. Below Crowfoot Creek it receives no tributary which carries running water at all seasons, and the whole region is without doubt arid.

The portion of the South Saskatchewan below the confluence of the Bow and Belly has been described in connection with the latter river. (p. 26 c).

COUNTRY BETWEEN THE BOW AND RED DEER RIVERS.

The following notes, with those on the Red Deer River, are by Mr. McConnell.

"In a traverse made from the Blackfoot Crossing to a point on the Red Deer River, about five miles below the mouth of the Arrow-wood, the country passed over was found to be almost entirely of a rolling character.

Lord Lorne trail.

"Leaving the Blackfoot Crossing on this trail, the country gradually rises until the summit of the Wintering Hills is reached. These hills, although their slope southward is very light, present a steep escarpment to the north. From their base the country continues rolling to the river. The soil over most of this region consists of a greyish or yellowish loam, the loam passing occasionally into almost pure sand or clay. A varying quantity of gravel is also usually present. This country seems to be especially adapted to summer grazing, the grass being very good and the supply of water quite sufficient.

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"After descending twenty miles, the trail low country becomes of clay and gravelly and quite

"Speaking of the Red Deer and exception of a few of drifting sand hills which are very scanty and improves rapidly and many of the

"The valley of the wood, the point for about twenty miles, and in the middle of it an extremely narrow section

"Below that the valley gradually becoming hills sloping in depth to about

"Approaching the series. High series, the 11th meridian rule wider and series of a few miles the way.

"The Red Deer is usually sandy, the way down, the age rate of about

"After descending the Red Deer River in a canoe to a point about twenty miles below the crossing of the Lord Lorne trail, another traverse was made from that point back to the Blackfoot Crossing.

"This trail passes for a number of miles over low sandy ridges, separated by wide shallow depressions containing alkaline lakes. East of the trail low sand hills were seen. Approaching Crowfoot Creek the country becomes more rolling and the soil contains a larger proportion of clay and gravel. The grass along this trail is inferior both in quantity and quality to that further west. Country east of Lord Lorne trail.

"Speaking generally, the country included on the map between the Red Deer and the Bow and east of the Lord Lorne trail, is with the exception of a few limited areas, of a very inferior description. Areas of drifting sand-hills are of frequent occurrence, while the dry rolling hills which characterize the greater part of the region support but a very scanty vegetation. West of the Lord Lorne trail the country improves rapidly, the grass covering the hills grows longer and thicker and many of the hollows contain small fresh-water lakes. General character of surface

RED DEER RIVER.

"The valley of the Red Deer River, from the mouth of the Arrow-wood, the point where my examination commenced, down the stream for about twenty miles, varies in width from half a mile to a mile and a half, and in depth from 350 to 550 feet. Its steep naked banks give it an extremely cañon-like appearance and afford magnificent and continuous sections of the rocks overlying the Pierre shales. Valley of Red Deer

"Below that point the influence of the Pierre shales makes itself felt, the valley gradually widens and the scarped banks are replaced by rolling hills sloping easily up to the prairie level. Further down, the slopes become more even and are covered with grass, and the valley decreases in depth to about 200 feet.

"Approaching Hunting Hill, scarped banks re-appear, and the valley is again narrowed in by the harder rocks belonging to the Belly River series. High scarped banks prevail nearly all the way down to the 111th meridian. Between this point and the forks, the valley is as a rule wider and shallower than it is further up, and with the exception of a few miles at one place, the banks are grass-covered nearly all the way. Hunting Hill.

"The Red Deer River varies in width from 150 to 300 yards, its bed is usually sandy, and sand-bars and sandy islands occur at intervals all the way down. The current at the beginning of July ran at an average rate of about one and three quarter miles per hour."

DESCRIPTIVE GEOLOGY.

Formations
represented

The rocks described in this report, exclusive of the boulder-clay and other "drift" deposits, are referable to the following series :—

LARAMIE	{ Porcupine Hill beds. Willow Creek beds. St. Mary River beds.
CRETACEOUS	{ Fox Hill sandstones (inconstant). Pierre shales. Belly River beds. Dark shales of Rocky Spring Ridge, etc., supposed to underlie the last.

A more detailed description, with a discussion of the relations of these beds, will be found on a subsequent page.

SECTION ON MILK RIVER, AND IN THE VICINITY OF THE 49TH PARALLEL.

SWEET GRASS HILLS.

General
character of
section.

The Milk River flows across the 49th parallel northward near the 113th meridian, and after pursuing an eastward course of about one hundred and fourteen miles, recrosses the same parallel about twenty miles east of the 111th meridian, a short distance beyond the limit of the district embraced by the present map and report. It is ten miles north of the 49th parallel near the crossing of the MacLeod-Benton trail, this being its most northern point.

Taking into consideration the length of the stream, the rock section is much inferior to that afforded by some other rivers in this region, but still presents a few points of special interest. In this portion of the report it is proposed to describe its geological features briefly, and to include such geological notes as may be necessary of the country lying to the south of the river as far as the edge of the map.

North branch.

Where the Milk River first enters the district, it is flanked to the west by a plateau which may be considered as forming the western prolongation of the Milk River Ridge. The rocks here shown in the immediate valley of the river, have been described by me in the Report on the Geology and Resources of the 49th Parallel (p. 131) where this part of the stream is designated as the Second Branch. They belong to the St. Mary River subdivision of the classification now adopted. The banks show about fifty feet of pale bluish- and greenish-grey sandstones and sandy shales, generally soft, but with a few harder layers consisting of calcareous and ferruginous sandstone bands. In one of these, which may be described as a nodular ferruginous limestone of about a foot in thickness, and is at a level of about forty feet

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above the stream, numerous fossils were found. These include *Bulinus disjunctus* (?) *Limnaea*, *Physa*, and *Sphærium*.

In 1874 a loose block of similar material was found about fourteen miles eastward, at the crossing of the 49th parallel and South Branch of Milk River (First Branch of report above quoted), and the bed above referred to is again evidently the same as that described in a subsequent page as occurring on the upper part of the St. Mary.

The plateau alluded to as flanking this part of the river, is traversed by one or more narrow valleys, the scarped sides of which show 150 beds. Plateau of Willow Creek beds.
to 200 feet of reddish and purplish-grey clayey and sandy beds belonging to the Willow Creek subdivision of the Laramie. These beds have a light eastward dip, and though for a considerable part of the distance between the Milk and St. Mary rivers no exposures are found, the western edge of the plateau formed of the Willow Creek beds is so well defined, that there is every reason to believe that the lower country at its western base marks the position of a low anticlinal, which separates this area of the Willow Creek from that occurring on the St. Mary.

From the point at which the Milk River crosses the 49th parallel, for about ten miles north-eastward, the rocks observed are chiefly sandstones of brownish and yellowish-grey tints. These, in several of the lateral ravines, assume monumental forms from the unequal resistance of the several layers to weathering. At the point last defined, rather massive beds of these sandstones are found, on the south bank of the river, to be underlain by the blackish shales of the Pierre, and they may therefore be assumed to represent the Fox Hill series, but possibly also include the lower beds of the St. Mary River subdivision. The discovery of the Pierre shales, which, owing to the rounded character of the banks are here very poorly exposed, is due to Mr. R. G. McConnell. These shales are here, probably, much thinner than further north, and cross the valley with a width of less than three miles. They appear to form the southern edge of the plateau of the Milk River Ridge, which here borders the valley to the north, for about seven miles, or nearly to the point at which the Lonely Valley enters. Beyond this point, for about five miles, the river flows south-eastward, and cuts through a higher tract of country, forming a narrow and almost cañon-like valley, three hundred feet in depth and less than a mile in width from rim to rim. The rocks here shown belong to the pale upper portion of the Belly River series, and underlie the Pierre shales above referred to. They consist chiefly of greenish-grey sands and sandy clays, and thin layers of soft sandstones with calcareous or ferruginous concretions. They are to all appearance horizontal, and no fossils were observed. These rocks and the Pierre shales were more carefully

Sandstones at base of Laramie.

Pierre shales.

Canon near Lonely Valley. Belly River series.

studied in the Milk River Ridge to the north, and their relations are described on a succeeding page.

Sections near
South Branch.

South of the Milk River, and near the 49th parallel, about six miles west of the South Branch, rocks belonging to the same area of the Belly River series were observed by me in 1874, though at that time erroneously supposed to belong to the "Lignite Tertiary" of my report.* As this locality has not since been visited and the volume referred to is now out of print, the following description of these rocks is quoted from it:—

Belly River
series.

The best exposures are found in a group of small hills, which assumes in miniature the appearance of bad-lands, and stands like an island of older rocks among the drift deposits, which lap around its base. It is an outlier of a plateau, which, with irregular edge, runs northward with a little easting where it crosses the line. The beds are horizontal, and are exposed for a thickness of about sixty feet. The lower portion of the section is of pale greenish-grey clays, while above, the greenish colour is not so marked, and there are somewhat massive sandstones. In some places the latter are almost conglomerates, and hold many small pebbles, the majority of which are of greenish shale. They also hold fragments of reptilian bones and large *Unio* shells. Small nodules occur abundantly in some layers of the lower greenish clays, of a tint similar to the matrix. The bones are found in considerable abundance in all parts of the section, but are much crushed and fissured. When imbedded in the bank they are purplish-black in colour, but on weathering assume whitish and rusty tints. It is very difficult to dig the bones out of the bank itself, from the great hardness of the dry clay relatively to that of the fossils, and where washed out by the rains they are found only as broken fragments, difficult to re-construct. From specimens obtained here, however, in the course of a few hours, Prof. Cope finds, besides many broken fragments of Dinosaurs, new species of *Cionodon* and *Compsemys*, which he has called *C. stenopsis* and *C. agmus*, respectively.

Dinosaurian
remains.

The greenish clay beds are doubtless formed of the disintegrated material of beds of green shale, similar to those represented by the pebbles in the conglomerates. A microscopic examination of the clay did not reveal any recognisable fragments of green mineral or rock, the colour apparently residing in the very fine argillaceous matter, through which a few large partly rounded grains of transparent quartz are scattered.

South Branch.

The South Branch of Milk River where examined by me near the 49th parallel in 1874, shows drift deposits only. Between this point and its

* Geology and Resources of the 49th parallel, p. 130.

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mouth, the valley shows at one point yellowish-weathering sandstones irregularly hardened and bedded, and holding some ironstone. These appear to be practically horizontal. Several miles further down, near the confluence of this with the North Branch, these beds re-appear, with much the same aspect, but are overlain by beds of a different character, which, from analogy with those seen in the Milk River Ridge and elsewhere, with little doubt represent the base of the Pierre. These are well shown in a scarped bank about one hundred feet high, a mile and a quarter up the South Branch, and consist of greyish and blackish well-bedded shales and shaly sandstones, containing one highly carbonaceous layer which almost resembles a coal. The bedding of the whole is very uniform, but no regular direction of dip could be determined. A few fragments of shells, among which is a *Unio*, occur.

In following down the main valley of Milk River below the mouth of the South Branch, sections occur at frequent intervals for some miles, of beds quite similar to, and evidently on the same horizon with, those last described. The carbonaceous character of the beds here, however, becomes more pronounced, and they hold three or four coal seams which occasionally attain a thickness of over six inches. After a concealed interval of about a mile and a half, at a point about four miles west of the MacLeod-Benton trail-crossing, yellowish and grey sandstones of variable hardness and appearance, again appear. These were at the time regarded as probably overlying the Pierre shales last described, but as more fully shown on a succeeding page, reasons have since been found to show that they probably represent those described as occurring at the mouth of the South Branch, and really underlie these shales.

Sandstones of the character of those just described were the only rocks seen in the Milk River valley from this point eastward for many miles, but the exposures are infrequent and small on this part of the river. East of the trail-crossing, occasional outcrops occur in low bluffs. At a point four miles east, a small section of grey, yellowish-weathering sandstones with intervening yellowish-grey and blackish shaly beds, holding *Nucula cancellata*, was examined. There is here an appearance of slight northerly dip which may, however, be merely a local undulation.

Ten miles south of this part of Milk River, very similar rocks are again exposed in the valley of Red Creek, where it crosses the 49th parallel. In a bank about seventy feet high the following succession of beds was observed, though no exact measurement of them was made:—

Gravel and boulders, underlain by obscurely stratified drift	10 feet.
Greyish and yellowish, sandy shales	30 feet.
Yellowish, soft, clayey sandstone	
Purplish-grey shale	
Yellowish sandstone	

Base of Pierre
shales, coal
beds.

Exposures east
of trail-cross-
ing.

Red Creek.

Yellowish, shaly sandstone.....	} 30 feet.
Irregular, harder, yellowish sandstone.....	
Greyish sandy shales, with thin layers of blackish carbonaceous clay at base.....	

The beds are here believed to have a low northerly dip, and rise southward and eastward with the general surface of the country to the summit of the Rocky Spring Plateau, south of the 49th parallel, where they are probably represented by those forming the upper layers in the section in the eastern escarpment of this plateau, referred to on a succeeding page.

Sandstone
outcrops.

From the point on Milk River last alluded to—four miles east of the trail-crossing—to the mouth of Verdigris Coulee, sandstones not dissimilar in appearance to those above described are seen at intervals, but generally in small exposures, and presenting no points of special interest. They appear throughout to be horizontal, or affected by light indefinite undulations only, but the sections are so inconsiderable that it is by no means certain that sandstones really preponderate among the rocks of this part of the river. It is frequently the case throughout this district that the harder sandstone layers alone appear in the rounded and grassy banks, while other and more characteristic beds, owing to their inferior induration, are concealed.

Mouth of Verdigris Coulee.

The rocks exposed on Verdigris Coulee are described subsequently, in connection with those of Milk River Ridge. At its mouth, a peculiar series of castellated or monumental sandstones first appears, the summit being here not much above the level of the Milk River, and overlain to the north by the beds seen further up Verdigris Coulee. From this point to that part of the river immediately north of the West Butte (nine miles) and beyond into Dead Horse Coulee, these sandstones appear almost uninterruptedly, and disregarding minor undulations, they rise persistently eastward and attain a greater height in the banks. They often characterize both sides of the valley, and though occasionally forming vertical cliffs, generally weather out into fantastic monumental forms, one group of which has already been illustrated in connection with the preliminary note on the geology of this district.* The greater part of the sandstone is soft and whitish, but certain harder, finely stratified or false-bedded layers, generally yellowish in color, have served as protective cappings, or project in cornice-like forms, which in some of the lateral ravines give rise to very remarkable instances of weathering. At a point three miles east of Verdigris Coulee, the sandstones were observed to be roughly false-bedded and to include blackish shaly intercalations and rolled fragments of shale, indicating proximity

Castellated
sandstones

* Report of Progress Geol. Surv. 1880-1882.

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to, and some local mile further east stones, and doubt the Rocky Spring Coulee. The thickness where greatest is not well shown there. Here, sandy beds, which contain bonaceous matter, holding occasional stone, in which not the last mentioned Horse Coulee to it absence of calcareous characteristic and

In going from Coulee, to the westward—the country to follow the slope valleys. The mass Butte, elsewhere of castellated rocks of

The tract south Red Creek was examined. Though numerous are a rule small and unare found to assume the base of the Butte a position much higher to. This sandstone light eastward dip, escarpments of a low sandstones evidently appear, and are doubt edge of the Rocky Spring the report already seen

In a system of ravines of the Butte, these sandstones estimated thickness much below the general parts of the banks, appearance. The local

to, and some local denudation of, the underlying series. This, about a mile further east, was observed in small exposures below the sandstones, and doubtless represents the upper part of the shaly series of the Rocky Spring Plateau (p. 42 c) and that of the mouth of Pā-kow-ki Coulée. The thickness of these sandstones is rather variable, but where greatest is about seventy feet. The beds overlying them are not well shown till that part of the river north of the West Butte is reached. Here, about one hundred feet of softer brownish and greyish sandy beds, which at times becomes blackish from the addition of carbonaceous matter, appear, and are interbedded with friable sandy clays holding occasional nodularly hardened layers of sandstone or ironstone, in which no fossils could be found. The same sandstones, with the last mentioned overlying beds, continue in the banks through Dead Horse Coulée to its east end, though in consequence, apparently, of the absence of calcareous matter, the castellated forms here become less characteristic and eventually cease to appear.

In going from the Milk River, near the west end of Dead Horse Coulée, to the west flank of the West Butte—eight miles south-westward—the country gradually rises, and the beds above described appear to follow the slope and are seen in isolated exposures in some of the valleys. The massive sandstone observed on the west flank of the Butte, elsewhere described, is doubtless the same which forms the castellated rocks on the Milk River.

The tract south of the Milk River and between the West Butte and Red Creek was examined by me in 1874, and has not been revisited. Though numerous exposures occur in the various coulees, they are as a rule small and unsatisfactory. Westward from the Butte, the beds are found to assume a gentle synclinal form. About six miles from the base of the Butte, a zone of sandstone appears, which seems to hold a position much higher in the series than that on its flank, above referred to. This sandstone, two miles further west, was again seen, with a slight eastward dip, the two outcrops forming the eastern and western escarpments of a low plateau. A short distance west of this synclinal, sandstones evidently representing the castellated beds of Milk River appear, and are doubtless also the same with those capping the eastern edge of the Rocky Spring Plateau. These beds are thus described in the report already several times referred to:—

In a system of ravines south of the line, about twenty miles west of the Butte, these sandstones are again well exposed, and have an estimated thickness of thirty feet. In these valleys they occur not much below the general level of the prairie, and forming the upper parts of the banks, give them a most picturesque and remarkable appearance. The lower layers of the sandstone are generally very

Underlying
shales.

Rocks near
West Butte.

Rocks west of
West Butte
near Boundary
line.

regularly bedded, and some of them are exceedingly fine and thin, and show worm-tracks and obscure markings. The upper beds are more massive, and have a nodular character, which causes them to weather out into castellated forms, resembling in some places those of the Roche Percée. Underlying the sandstones are less permeable clays, or arenaceous clays, of light colours, of which I did not succeed in finding good exposures, but which turn out numerous springs of a highly saline character. The beds appear to be quite horizontal in this locality.

Rocky Spring
Plateau.

The escarpment mentioned in the succeeding paragraph of my Boundary Commission report is that of the Rocky Spring Ridge or plateau.* Originating near the place last described, it runs south-eastward, gradually increasing in elevation, till, where crossed by the MacLeod-Benton trail, at a distance of fourteen miles, it has a height above the plains at its eastern base, of over 800 feet. The following section, in descending order, was measured near the point at which the trail descends from the plateau:—

	FEET.	INCHES.
1. Beds imperfectly exposed, but evidently soft, and wherever seen greyish, shaly sandstones, or sandy shales, thinly bedded.....	90	0
2. Sandstones, one rather massive bed of thirty to fifty feet near the top. Other beds flaggy sandstones, passing in some places into sandy shales. The bedding of all the sandstones regular, and surfaces often showing ripple-marks and annelide tracks. Two series of jointage-planes, causing the beds to weather into castellated forms. General colour on weathered surfaces, dark brownish.....	135	0
3. Pale greyish, and in places yellowish-grey sandy shales, all finely bedded, and occasionally holding calcareous nodules.....	90	0
4. Grey, finely-bedded sandy shales, rather hard. (Fossil bed No. 2.) <i>Baculites</i> , <i>Inocerami</i> , &c.....	20	0
5. Lead-grey, soft sandy shales.....	55	0
6. Ferruginous ripple-marked sandstone. (Fossil bed No. 1.).....	0	6
7. Lead-grey and blackish, thin sandy shales, with lenticular masses of dark argillaceous limestone, and calcareous concretions.....	70	0
	460	6

* The south-eastern front of this plateau, is roughly represented on some maps, and named the Snake Head Hills.

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From the base of about 300 feet, composed of black River.

The Sweet Grass described together with the description of the bends abruptly evidently of con valley, now dry, through eastward further on. On the sandstones and sand three miles north here runs parallel thickness and of whitish soft sand more further north there is some reason layers of lignite and

About half a mile valley, the sandy replaced in the bed seen, but the shale distance further east which seem to be exposed. At a point found capping the the greater part is yellowish in general with those more fossiliferous. East of the anticlinal or perhaps the shales alone are generally soft sand the section, and east dip, to Pa-kow-ki (

It is probable that and runs into the mountain pretty evident evidence of the igneous dark mica-trap ap which it joins

From the base of this section, the beds are concealed for a thickness of about 300 feet, when the surface of the lower plain is found to be composed of blackish shales, which continue southward to the Marias River.

The Sweet Grass Hills and country immediately adjacent to them, are described together on a subsequent page. From the point to which the description of the rocks on Milk River has been carried, that stream bends abruptly to the north, following a narrow valley which is evidently of comparatively recent origin, while a wide trough-like valley, now dry, and above alluded to as Dead Horse Coulée, runs through eastward, and is again joined by the river six and a half miles further on. On the river to the north of this valley, a few exposures of sandstones and sandy-clays with ironstone were seen, and at one place, three miles north of the river, in the front of the low plateau which here runs parallel to it, a bed of lignite-coal, three feet six inches in thickness and of fair quality, occurs. This is underlain by a few feet of whitish soft sandstone, but the exposure is small. For a mile or more further north, similar pale sandy beds are occasionally seen, and there is some reason to suspect a light southerly dip. Unimportant layers of lignite also appear in the banks of Dead Horse Coulée.

About half a mile east of the east end of this coulée, in the Milk River valley, the sandy and generally pale beds shown in the coulée are replaced in the bank by dark shales. The actual junction was not seen, but the shales are supposed to be the underlying series. A short distance further east, these shales are again replaced by sandstones, which seem to occupy a light synclinal, but are here very poorly exposed. At a point five miles west of the Pā-kow-kī Coulée, they are found capping the high bank of the river on the north side, of which the greater part is composed of the dark shales. These sandstones are yellowish in general tint, hold a few valves of *Ostrea* and are the same with those more fully described as occurring at the mouth of Pā-kow-kī Coulée. East of the point last referred to, in consequence of a light anticlinal or perhaps merely owing to the decreased height of the bank, the shales alone are seen for about two miles, when grey and yellowish generally soft sandy clays and sandstones again form the the summit of the section, and continue with increased thickness, due to a light easterly dip, to Pā-kow-kī Coulée.

It is probable that a light narrow anticlinal crosses the Milk River and runs into the mouth of Pā-kow-kī Coulée. The coulée is, in any case, in pretty evident connection with the existence of a subordinate intrusion of the igneous rocks of the Sweet Grass Hills. A small mass of dark mica-trap appears in the middle of the coulée near the point at which it joins the river. This includes fragments of hardened

Milk River
near Dead
Horse Coulée.

Coal seam.

Dead Horse
Coulée to Pā-
kow-kī Coulée.

Mouth of
Pā-kow-kī
Coulée.

Trap intrusion.

blackish shale, and is much cracked and fissured. Calcite, pyrites and some zeolitic mineral occur in small quantities. A similar little trappean projection, which may be connected with this, is seen about two miles off to the south-east on the opposite side of the river. The dark shales and shaly sandstones occur on both sides of Pā-kow-kī Coulée at its mouth. They form about eighty feet of the lower part of the bank to the west, but are not so well exposed to the east, owing to the persistent light easterly dip which here affects the strata. In both places the overlying rocks are grey sandstones and sandy clays, some layers of which are charged with innumerable well preserved specimens of *Ostrea glabra*. On the opposite or south side of the valley of the river the shales are not seen. In the spot first referred to, they hold a few badly preserved fossils, among which fragments of *Nucula cancellata* and *Liopisthes (Cymella) undata* were detected.

Milk River
east of Pā-kow-
kī Coulée.

For some miles eastward from the Pā-kow kī Coulée there are fine exposures of the banded sandstones and clays above referred to. These beds are evidently the same with those observed on the Lower Belly and Bow, and on the South Saskatchewan, and belong to the Belly River series of this report. They include, east of the coulée, some beds rich in molluses, among which *Corbula subtrigonalis*, *Corbula perundata*, *Neritina baptista*, (?) *Melania insculpta*, a *Rhytrophorus*, a *Viciparus* and a *Goniobasis* have been determined. The following section was obtained about five miles below the mouth of the coulée in the north bank of the valley of the river:—

Belly River
series.

	FEET. INCHES.	
1. Greyish, sandy clays	6	0
2. Laminated, carbonaceous shale, with four-inch seam of lignite	6	0
3. Brownish and greyish, sandy clays	6	0
4. Shell-bed, with rusty, ferruginous cement. <i>Corbula perundata</i> , &c.	1	6
5. Lignite (variable)	0	4
6. Brownish and greyish clays, <i>Corbula</i> , &c.	12	0
7. Brown, thinly bedded, ripple-marked sandstone	0	6
8. Greyish, sandy clay, regularly bedded	4	0
9. Oyster bed	3	0
10. Brownish and greyish, banded sandy clays	70	0
11. Brown, hard sandstone	1	0
12. Greyish, sandy clay	10	0
13. Laminated, carbonaceous shale	1	6
14. Brownish-grey, sandy clays, many small <i>Ostrea</i>	132	0
Similar beds poorly exposed. To water of river		
	253	10

Adding one hundred feet to the section above, the total thickness is raised to about 350 feet. The dip is light eastward, but is diminished, even at the mouth of the coulée, here almost continuous, and the colours and earthy.

About seven miles eastward the beds become considerably more massive. The beds appear at the surface at eleven miles from the mouth of the coulée. The same high plateau is mentioned, and is measured on the north bank of the coulée, miles beyond the mouth of the coulée.

The rocks displayed here are known as the Sweetwater, but owing to the prevailing parties of opinion, the mountains lie to the west, and are not deemed expedient to describe in detail. The description of the geological section is given on page 16 c. Since the only point referred to in the following description is my Report on the geology of the Belly River series.

On approaching the Belly River, twelve miles, the dip is distinct, and the beds dip away from the river, which seam the flanks of the mountains. Numerous more or less distinct, sending the Belly River series necessary to describe.

Dykes of eruptive rocks, forming the Buttes, in the Belly River series, radiate from the base of the summit of the hills, and are wearing away of the surface, partly ruined.

* Geology and Resources.

Adding one hundred feet to represent the portion of the formation not included in the above section, the total thickness of these beds is raised to about 350 feet. The whole series has, as above stated, a slight eastward dip, and the beds above described can easily be distinguished, even at a considerable distance, in the scarped banks which are here almost continuous, from their prevalent brownish and yellowish colours and earthy appearance.

About seven miles below the mouth of Pā-kow-ki Coulée, the banks become considerably higher, and on the south side, paler ash-grey beds appear at the top of the section. These, at a distance estimated at eleven miles from the same point, form the upper two-thirds of the bank. The same upper pale portion of the Belly River series forms the high plateau south and south-east of Lake Pā-kow-ki, as elsewhere mentioned, and it is of this part of the series that a section was measured on the Milk River near the 49th parallel crossing, a few miles beyond the edge of the present map, in 1874.*

The rocks displayed in and about the remarkable isolated mountains known as the Sweet Grass Hills or Three Buttes are of great interest, but owing to the constant danger of having our horses stolen by wandering parties of Indians in this vicinity, and the fact that these mountains lie to the south of the International boundary-line, it was not deemed expedient to remain long in the neighbourhood. A general description of the Sweet Grass Hills, in which the main features of their geological structure are referred to, has already been given. (p. 16 c). Since my examination of the East and West Buttes in 1874, the only point re-visited has been the flank of the latter mountain, and the following description is, therefore, almost literally quoted from my Report on the Geology and Resources of the 49th parallel.

On approaching the East Butte from the north to within ten or twelve miles, the hitherto nearly horizontal beds are found to assume a distinct dip away from its central mass. In the valleys of the streams which seam the flanks of the hills and furrow the surface around them, numerous more or less extensive exposures of rocks evidently representing the Belly River series of this report, occur, which it is unnecessary to describe in detail.

Dykes of eruptive material traverse the sedimentary rocks surrounding the Buttes, in some places, and appear generally to have a direction radiant from the higher peaks. In a valley about ten miles north of the summit of the East Butte, one of these is well exposed. By the wearing away of the softer surrounding beds, it stands up like a massive partly ruined wall, the resemblance being increased by the fact

Upper part of
Belly River
series.

Sweet Grass
Hills or Three
Buttes.

East Butte.

Trap dykes.

* Geology and Resources, 49th Parallel, p. 120.

that the rock has been broken up by the weather into quadrangular blocks. Its observed course is nearly east and west. The rock is a mica-trap of dark greenish-grey colour, and not very hard, in which small tabular crystals of a brown mica are thickly scattered. It may probably originally have been of the same nature with the central masses of the Buttes, but has become more basic by the incorporation of portions of the surrounding sedimentary rock, and has acquired a different mineralogical character from this circumstance and from more rapid cooling. The clays and sandstones on either side are nearly horizontal, except immediately in contact with the dyke, where they are contorted and much altered. Valves of *Ostrea* are abundant in some of the surrounding beds, and specimens of *Corbula perundata* were also recognized.

Rocks
surrounding
East Butte.

On ascending the East Butte, the harder beds are found constituting more or less continuous ridges round the central mass, while the softer intervening strata are not usually well exposed. The total thickness of the beds seen is not very great, as the ground rises almost equally with the increasing dip. The sedimentary rocks, in some places, rise to within about one thousand feet of the summit, and are then found much hardened and altered, and dipping very steeply away from it. They are here traversed, like the igneous rock itself, by many small seams of crystalline quartz, in which a careful examination failed to detect a trace of any metallic mineral.

Sequence of
rocks, East
Butte.

Nearest the igneous mass, and lowest in the series, on the East Butte occur beds of hardened sandstone, not of great thickness. On these rests a considerable thickness of hard, blackish, fissile shale, in which no characteristic fossils were found, but which doubtless represents those subsequently described as occurring at the West Butte. Above this is a rather important sandstone series, much of which is regularly bedded, but which in some places is nodular, and gives rise in the valleys which cut through it, to castellated, step-like and fluted rocks of picturesque appearance. These, with little doubt, represent the castellated sandstones described on Milk River, and are followed by the beds above alluded to as probably referable to the Belly River series.

Eruptive
central mass.

The igneous material composing the higher peaks and central masses of the mountains, though very hard and compact, is seldom seen actually *in situ*, the solid rock being concealed under a great depth of its own fragments. These fragments are very irregular in form, but generally angular, bounded by plane faces, and vary in size from a few inches to about two feet in greatest diameter. The rock is very uniform lithologically, in appearance and composition. Mr. F. D. Adams has examined microscopic sections of it, and states that it may be called a hornblende-trachyte, rich in plagioclase. Mr. Adams writes "it is composed of

orthoclase and hornblende. It is an andesite and trachyte, and only be ascertained by the highest peaks.

The highest peaks are large blunt-topped cliffs. West and east ridges, enclosing the foot-hills of those of the other Butte, found to be but a considerable portion of the ground caught up by the south-eastward at altered and now stones in which the Butte is indistinctly it forms shattered.

The clearest seen with on its western central valley. In those described on dip. The sections the thickness of the A few fossils were these shales, which group In consequence, the locality tional collections determined:—

Ostrea congesta, *biangulata*, *Scapha*

Underlying the stones tilted at high which evidently rise the East Butte. yellowish in colour a prominent ridge the west flank of the and a thickness of

* I have been credibly

orthoclase and plagioclase, both present in large amount, and some hornblende. It is therefore intermediate in composition between andesite and trachyte, and to which class it may best be referred can only be ascertained by a partial analysis."

The highest peak of the West Butte, is at its eastern side, and is a West Butte. large blunt-topped mountain, which to the east presents vertical rocky cliffs. West and north of this summit lie several important peaks and ridges, enclosing a rugged, pine-clad and rocky area of some extent. The foot-hills of the West Butte are also on a larger scale than those of the others. The sedimentary rocks are, as in the East Butte, found to dip away from the central igneous intrusion on all sides, but a considerable mass of stratified rock has here been, as it were, caught up by the eruptive material, and occupies the depressed central portion of the group of mountains. A great part of these beds dip south-eastward at a rather high angle. They have been considerably altered and now consist of slaty shales, and hard, thin-bedded sandstones in which no fossils were found. The trappean nucleus of this Butte is indistinguishable lithologically from that of the East Butte, and it forms shattered and rubbly hill-tops in the same way.*

The clearest sections of the rocks surrounding this Butte were met with on its western side, where a considerable brook issues from the central valley. Dark, somewhat indurated shales, precisely resembling those described on the East Butte, here occur, with a light westward dip. The sections are not such as to admit of exact measurement, but the thickness of the shales was roughly estimated in 1874 at 800 feet. A few fossils were found in sandy and nodular layers associated with these shales, which were at the time supposed to represent the Pierre group. In consequence of the importance of deciding their relations, the locality above described was again visited in 1881, and additional collections obtained, in which the following species have been determined:—

Ostrea congesta, *Pteria Nebrascana*, *Pyrius Newberryi*, *Aporrhais biangulata*, *Scaphites Warreni*, *Baculites ovatus*, var., etc.

Underlying these clay-shales in some places, are rather massive sandstones tilted at high angles against the flanks of the eruptive rock, which evidently represent those found occupying a similar position on the East Butte. Overlying the shales, are massive sandstone beds, yellowish in colour, which, from their superior hardness, generally form a prominent ridge at a little distance from the base of the Butte. On the west flank of the Butte these dip away at an angle of about 12°, and a thickness of over forty feet is exposed. The investigations of

* I have been credibly informed of the occurrence of galena on the east side of the West Butte.

1881-83 appear to show that the shales here described represent those of the Rocky Spring Plateau and Milk River north of the Buttes, while the overlying sandstones are those referred to as the castellated series on the same river.

Age of the
Buttes.

With regard to the age of the isolated igneous masses here so prominently displayed, all that the sections prove is that they are later than the surrounding Cretaceous rocks, which have been disturbed by them and are cut by their dykes. They are probably protrusions quite local in character, though with possible deep-seated connection with the similar intrusive masses near the Missouri to the south. They have not, however, at all the character of modern volcanic cones, and no rocks were seen in connection with them which had even probably cooled at the surface. If of the nature of volcanoes they must be very ancient ones, of which the cones or stumps now only remain, and from about which the whole of the ejected material has been removed. The denudation affecting the rocks tilted up round the Buttes has been very great, and must have occurred for the most part in Tertiary time and before the glacial period.

MILK RIVER RIDGE AND VICINITY.

Milk River
Ridge.

The following notes are based in part of Mr. McConnell's work in 1882 in part on my own in 1883.—Milk River Ridge is a rough irregular plateau varying in width from six to twelve miles, and extending from near St. Mary River, eastward, parallel to the Milk River for about forty miles. Its northern edge is rather abrupt, and rises in some places as much as 600 feet above the plains. Its southern border is not so well defined and is worn into a succession of deep bays by small streams which flow into Milk River. The Lonely Valley cuts completely through its western portion, and there are several similar but less important gaps running through it from the Milk River valley near its intersection with the 49th parallel. The plateau to the south-east of the South Branch of Milk River, is evidently a portion of the same area of high land which constitutes the Milk River Ridge proper. As already stated on a previous page of this report, the plains to the north of the ridge are at nearly the same level as—and in many places even lower than—the water of Milk River to the south.

Complex geological
structure.

Milk River Ridge is remarkable on account of its complex geological structure. Its western portion, composed of beds of the Willow Creek subdivision of the Laramie, has already been noticed in connection with the description of sections on the upper Milk River (p. 37 c). In proceeding eastward the St. Mary River subdivision, the Fox Hill, Pierre and Belly Rivers beds, are found to outcrop successively, in consequence of a light westerly dip, which, though locally interfered with by light

undulations, a series, though in no place of land above all, probably chiefly connected with it these were seen River series. composed of the F of the Fox Hill plateau, in a low where Mr. McC

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*Compare with its dev

undulations, appears on the whole to be persistent. The last named series, though well displayed in the eastern part of the ridge, was in no place observed to form the surface of the plateau. The high land above alluded to as existing south-east of the South Branch, is probably chiefly composed of Pierre shales; and in bare plateaus connected with it to the south-west, some miles south of the 49th parallel, these were seen from a distance overlying the pale beds of the Belly River series. The central and eastern portion of the plateau is composed of the Fox Hill, Pierre and Belly river beds. The sandstones of the Fox Hill, are well exposed about seven miles north of the plateau, in a low hill which is cut through by the Pot-hole River, where Mr. McConnell observed the following section:—

	FEET.
Yellowish-weathering, soft, coarse sandstone, showing branching fucoidal markings in many places.....	60
Black shales.....	15
Flaggy sandstones.....	20
Black shales (to base of section).....	60
	<hr/> 155

Fox Hill
sandstones.

The massive sandstone forming the top of this section, and which undoubtedly represents the Fox Hill,* forms a steep cliff facing the stream and extending up it about half a mile. Following the strike southward, it is again seen in conspicuous exposures about half way up the northern slope of Milk River Ridge, where the castellated and fantastic forms which this rock frequently assumes on weathering are well displayed.

In the valley of the west branch of Pot-hole River, where it leaves the plateau, the sandstones above described form the upper part of the section, and overlie about one hundred and fifty feet of black shales. The occurrence of this sandstone on the Milk River, south of the plateau, has already been alluded to. It is there about sixty feet in thickness.

To the east of the outcrop of these sandstones, the Pierre shales come to the surface in a belt of which the width is extremely variable. North of the plateau the outcrop is about five miles in width, but in following it southward it is found to spread eastward over the entire summit of the plateau, and reaches probably to within a few miles of the MacLeod-Benton trail; while the western edge, or summit of the shales, appears to run almost directly across the plateau to the Milk River. In many places along the northern slope of the plateau, the valleys of small streams afford good sections of the base of the Pierre, and the clays, sandstones and sandy clays of the underlying Belly River series. Of these the best observed are in and near Fossil Coulée, about

* Compare with its development on the neighbouring part of St. Mary River.

Coal seam.

Belly River
beds.—Section
on Fossil
Coulée.

ten miles west of the Nine-mile Butte. The actual base of the Pierre is best shown in the head waters of a small stream which flows into Middle Coulée Creek. The shales here to some extent lose their characteristic dark tint, become greyish or brownish and earthy looking, and hold several small seams of coal and carbonaceous shales. The most considerable coal seam is not more than eighteen inches thick, and the section here is closely comparable with that previously described in Milk River south of the ridge (p. 39 c). An oyster-bed identical with that observed at the mouth of St. Mary River at the same horizon, occurs in association with the coals. In this, in some places, the calcite of the shells has been largely replaced by iron oxide. The exposures on the head-waters of Ed. Mahan's Coulée are small, but probably represent the top of the Belly River series. On Fossil Coulée, fine exposures of the series last mentioned occur, in bare, bad-land banks. The following is a section of the greater part of the beds there shown, in descending order:—

	FEET.	INCHES.
Dark grey, soft, sandy clay.....	6	0
Yellowish sand or soft sandstone.....	4	0
Grey, soft sands, with some bands of clay.....	15	0
Grey, soft sandstone.....	1	0
Greenish-grey clay.....	5	0
Grey, soft, shaly sandstone.....	1	0
Grey, soft, sand and sandy clay.....	4	0
Greenish-grey clay.....	5	0
Nodular layer of impure calcareous ironstone.....	1	6
Yellowish, fine sand, or soft sandstone.....	4	6
Dark grey, sandy clay.....	3	6
Greenish-grey sands, irregularly hardened and forming projecting cornice-like layers of sandstone..	8	6
Greenish clay, with large impure septarian ironstone nodules.....	8	0
Greenish-grey, sandy clays and clays.....	10	0
Yellowish-grey, sandy clay, with layer full of small clay pebbles at top.....	10	0
Yellowish-grey, fine, soft sand.....	3	0
Brown-weathering, snaly sandstone, becoming conglomeritic with small clay pebbles in some places (locally developed).....	1	6
Grey, soft, fine sand.....	3	0
Grey, fine-grained sandstone.....	1	0
Pale greenish-grey clay, slightly banded.....	15	0
Pale greenish-grey, soft, sandy clay.....	4	6
Grey, soft, clayey sand. The upper portion full of small soft ironstone concretions.....	3	0
Grey, soft sandstone.....	0	2
Greyish, soft, clayey sand.....	5	0
	123	2

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This section or pale po accompanied by fossils. The fossils are collected from some of the these are : (fragment), The eastern to the lack of probably cre Mahan's Coulée form in appearance to the mass of which sandstone feature, scarcely however, are of the same observed in the Inoceramus, of the exposures the slopes of the recently continued ridge and those Coulée, a thin sandy clays, the hard nodular calcite lining the somewhat unexposed Pierre. Two of and *Vicparus* with Middle Coulée appear, which probably bank of Middle Coulée carbonaceous layers but the exposure are occasional about three miles same horizon with scarped banks with considerable exposure

This section may be regarded as a representative one of the upper Fossils. or pale portion of the Belly River series. Mr. T. C. Weston, who accompanied me to this locality in 1883, made here a considerable collection of fossils, which included *Unio* and other fresh-water shells resembling those abundant in the lower yellowish portion of the Belly River series. These were unfortunately lost *in transitu*. Mr. McConnell collected from the same locality, in 1882, a few fossils which indicate that some of the beds are brackish-water or marine in character. Among these are: *Pteria Nebrascana*, *Cymbophora alta* (?) *Volsella*, *Natica* (fragment), *Anchura*, *Spirocnema*, *Anodonta* and *Unio*.

The eastern edge of the Pierre shales on the Milk River Ridge, owing to the lack of exposures, can only be very approximately defined. It probably crosses the ridge nearly opposite the head-waters of Ed. Mahan's Coulée. These shales are, wherever seen in this region, very uniform in appearance. With the exception of the lower beds above alluded to, the mass of the series appears to be made up of very dark shales, in which sandstone beds, which in some other localities form a prominent feature, scarcely occur. Thin layers of red-weathering ironstone, however, are occasionally found, and numerous concretionary masses of the same material are scattered throughout. The only fossils observed in these beds in this neighbourhood were fragments of an *Inoceramus*, of an *Ammonite* and of a *Baculite*. General character of Pierre.

The exposures in Ed. Mahan's, Middle and Kipp's Coulées, north of the slopes of the ridge, are comparatively insignificant, and not sufficiently continuous to form a good connection between the rocks of the ridge and those of Verdigris Coulée. At the trail-crossing of Ed. Mahan's Coulée, a thin seam of lignite or shaly coal occurs in a bank of greyish sandy clays, the whole being underlain, in the bed of the stream, by a hard nodular calcareous layer, much fractured, and showing crystals of calcite lining the irregular crevices. The horizon of these beds is somewhat uncertain, but they may possibly represent the base of the Pierre. Two or more species of *Sphærium* and fragments of *Goniobasis* and *Viciparus* were obtained here. Near the junction of this coulée with Middle Coulée, yellowish soft irregularly bedded sandstones appear, which possibly underlie the beds just described. On the south bank of Middle Coulée, between this point and the trail-crossing, a carbonaceous layer, probably representing that above mentioned, occurs, but the exposures are poor. West of the trail-crossing on Middle Coulée, are occasional banks showing yellow sandstones and grey clays, for about three miles, where beds of the same character and on about the same horizon with those of Fossil Coulée appear, and are well shown in scarped banks west of the entrance of Middle Coulée Creek. Similar inconsiderable exposures occur both east and west of the trail-crossing. Rocks on Ed. Mahan's Middle, and Kipp's Coulées.

on Kipp's Coulée. These doubtless represent the Belly River series. In a narrow valley which connects Middle and Kipp's Coulées, west of the trail, scarped banks afforded the subjoined section :—

	FEET.	INCHES.
Greyish, flaggy sandstone.....	10	0
White, arenaceous clay.....	20	0
Yellowish sandstone (to base of section).....	8	0

Rocks on
Verdigris
Coulée.

Verdigris Coulée, already referred to in connection with the description of sections on the Milk River, affords almost continuous sections, for many miles, of the Belly River series; though from their character it is difficult to decide whether they represent its upper or lower portion. In the lower part of the coulée, near McConnell's Lake, the banks show a tendency to bad-land weathering and are in general tint greenish or purplish-grey. Yellowish sandstone beds are prominent and very irregularly hardened. Silicified wood is very abundant in some of the banks, but no other fossils were observed. The beds are to all appearance, perfectly horizontal. Similar beds at the same or nearly the same horizon, continue to and along the shores of Verdigris Lake, but are generally poorly shown. In the valley of a small stream which enters the lake from the south, near its north-west end, there are considerable sections of grey and yellowish shales and shaly sandstones, thin-bedded and rather hard; these appear to have a very light westward dip.

Fossiliferous
locality.

About a mile west of Verdigris Lake, in the north bank, a thin bed very rich in well preserved fossil shells of a few species, was found. Among these are *Corbula perundata*, *Corbicula cytheriformis* (?) *Ostrea* and *Unio*, but the specimens were unfortunately lost, with other collections from this district. The rocks in the vicinity are more thinly bedded than those near the mouth of the coulée. Thin yellowish and reddish sandstones occur, with pale or dark grey shales, which occasionally become impure lignite. Similar rocks, but in very imperfect exposures, in which the sandstones as a rule alone appear, occur on both sides of Tyrrell's Lake and westward to Suds Lake. Their horizontal attitude, wherever observed, and the absence of slope in the bed of the valley, would indicate that nearly the same horizon is represented throughout. Some of the beds on the higher part of the coulée present a marked resemblance to those seen at the trail-crossing of Ed. Mahan's Coulée, but it is impossible to trace out minor subdivisions of the series in this region.

Rocks on Etzi-
kom Coulée.

In Etzi-kom Coulée, about the meridian of the West Butte, sections were examined about fifty feet in thickness, which evidently represent

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the yellowish or lower portion of the Belly River series. The rocks seen were soft whitish sandstones and sandy clays, yellowish sandstones, and carbonaceous purplish-grey shales, which in some places approach lignite. They are apparently horizontal, *Ostrea glabra* (?) and a few other shells in a very poor state of preservation were observed.

Fourteen miles westward, on the same coulée, similar rocks, again associated with lignitic shales, and holding fragments of *Unio*, were noted by Mr. McConnell. A few miles west of Lake Pá-kow-kí on the same coulée, yellowish sandy-clays and sandstones, holding *Corbula perundata* were observed in 1881. This long coulée was not followed throughout its course, though Chin Coulée, running parallel to it a few miles to the north, was pretty carefully examined, and the horizontality of the beds leaves little room for doubt that practically the same horizon is represented on both.

The following notes on Chin Coulée are by Mr. McConnell:—

"Chin Coulée runs entirely through rocks belonging to the Belly River series, good sections of which occur at many points. The Chin, a name given to a small plateau lying north-east from the crossing of the Cypress trail and abutting on the coulée, is composed of brownish-yellow coarse sandstones, thickly bedded, and overlying some brownish flaggy sandstone. Section on Chin
Coulée.

"Between the Chin and a point about twenty-seven miles further east the coulée was not examined. Below that point, the banks of the valley are usually more or less scarped, and show almost continuous sections nearly all the way down to its mouth; the rocks consisting mainly of greyish sands and sandy clays, yellowish and greyish sandstone, lignitic shales and ironstone. Near the mouth of Forty-mile Coulée, a darker band containing a number of beds of carbonaceous shale appears in the section. Fossils were found in many places, *Corbula perundata*, *Corbula pyriformis* and *Ostrea glabra* being the most abundant. The last named fossil forms in one instance the greater part of two beds, in the same section, each about three feet thick. North of Chin Coulée and near the point where the Cypress trail crosses Forty-mile Coulée, a small coal seam, about fourteen inches thick, occurs. This seam is probably about the same horizon as the coal at Medicine Hat." Coal seam.

ST. MARY, UPPER BELLY AND WATERTON RIVERS.

The St. Mary, Upper Belly and Waterton (Kootanie) Rivers, flow north-eastward nearly parallel to each other, toward the main Belly River. The tract of country embraced between the first and last mentioned, scarcely averages over twenty miles in width, and the sections formed by these streams may in consequence well be treated together.

The slightly convergent courses of the Upper Belly and Waterton Rivers bring them together at a point about nineteen miles above the main Belly River, the united stream bearing the last mentioned name, though in point of volume and length of course, the Old Man River has a better claim to the title. As a matter of convenience, I have distinguished that part of the so-called Belly River which is above its junction with the Old Man, as the Upper Belly.

General
character of
sections.

The rocks exposed by the upper parts of these streams, from the base of the mountains, belong to the disturbed foot-hill belt. The rivers then cut across a considerable width of Willow Creek rocks, forming the southern extension of the wide synclinal in which, further north, the Porcupine Hills lie. They next traverse the rocks of the St. Mary River subdivision,—the river of the same name affording the best and most typical display of these rocks found in the district,—and enter the Pierre shale region before reaching the Belly.

Sections near
boundary-line.

The eastern edge of the disturbed belt crosses the forty-ninth parallel only a few miles east of the St. Mary River, so that the portion of that stream within the limits of the present report, which traverses the region of flexed rocks, is small; being in fact not more than about six miles. The rocks in the immediate vicinity of the boundary-line have been described in the Report on the Geology and Resources of the 49th Parallel (p. 132), from which the following notes are extracted with little change:—

Coal seam.

The lowest rocks seen in the part of the river nearest the line were at the Boundary Commission trail-crossing about two and a half miles north of the parallel. They are sandstones of greyish and yellowish tints, regularly bedded and quite hard, with some surfaces showing ripple-marks and worm-tracks. They have a south-westerly dip at an angle of 20°, and are present in considerable thickness. About half a mile south of these lower beds, and overlying the upper layers of the same sandstone zone, a bed of fuel with all the mineralogical characters of true bituminous coal, was found. It has a thickness of about eighteen inches only, and occurs just at the level of the water in the river, by which it is partly covered. It breaks with a clean fracture into cuboidal fragments with bright faces, and is indistinguishable in appearance from many coals of the true Carboniferous system. Below the coal is a foot or two of dark carbonaceous shale, somewhat indurated, and holding imperfect remains of plants. A similar shale, but only a few inches in thickness, rests upon the coal, and is followed in ascending order by a hard shell-bed eighteen inches to two feet thick, dark coloured from included carbonaceous matter, but in the main composed of shells of *Ostrea* and *Corbicula occidentalis*. Above this is a considerable thickness of flaggy and ripple-marked

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sandstones, greyish and brownish-grey, with a dip of S. 40° W. $< 35^{\circ}$. The ripple-marks indicate a current with a direction of S. 36° W.

A few hundred yards south-east of the last exposure, sandstones Anticlinal. similar to those overlying the coal are found in a steep bank. They are sharply folded into an anticlinal form, and are overlain by a considerable thickness of greenish-grey clay beds. The latter are charged with small flat masses of calcite, formed apparently in fissures, but now scattered over the surface of the clay-bank, giving it a remarkable appearance. A shell-bed very similar to that found in connection with the coal, but probably not identical with it, as it wants the carbonaceous colouring matter, also appears here. It probably underlies the sandstone, but though large blocks of it are strewn about, it is not well exposed. The rocks are so abruptly folded that they appear in some places to be slightly overturned, and in the absence of large and continuous sections, the precise relations of the beds cannot be traced.

Four miles west of the St. Mary River, and about two north of the Rocks west of St. Mary River. 49th parallel, a hard fossiliferous bed comes to the surface, forming the crest of a ridge. It dips west-north-west at an angle of 20° . Where exposed it is an almost solid mass of fossil shells, forming a rough limestone. The same molluscs are represented here as in the other sections in the immediate vicinity of St. Mary River. A short distance further west, a bed of hard sandstone appears, again forming the crest of a ridge, which can be traced for miles in a north-westward course. The strike of the sandstone itself, as shown by the stratification lines, is N. 20° W., with a south-westerly dip at high angles. The persistence of this bed in the direction of its strike, seems to show that though the strata are so much disturbed, the folding has taken place very regularly parallel to a single direction. The sandstone evidently underlies the shell-bed last referred to, and must be some hundreds of feet below it. It is yellowish, and not so much indurated as that seen in the river, some layers being still quite soft. In this bed was found a trunk of silicified wood.

The shell-bearing bed referred to in the above quotations, evidently Base of Laramie. represents the well-marked and wide-spread horizon of brackish and marine waters near the very base of the Laramie. It was not again seen on the St. Mary.

North of the old Boundary Commission trail, for a couple of miles, the river cuts its way between high rocky banks, and for a short distance becomes almost cañon-like. The sections here were not particularly examined in 1874, but this point was visited in 1881 for the purpose of connecting with the Boundary Commission work. The rocks displayed are those of the St. Mary River series, overlain by the Wil-

low Creek beds, characterized by their usual reddish colours. The strata in the part of the valley bordered by steep cliffs lie at various angles up to 40° , and the direction of dip is less regular than usual.

Section of St.
Mary River and
Willow Creek
beds.

The following section will serve more clearly to illustrate the character of the beds. The order is descending :—

	FEET.	INCHES.
1. Shales and sandstone interbedded, brownish and reddish-weathering, giving the bank a general ruddy appearance.....	20	0
2. Hard, yellowish-weathering sandstone.....	4	0
3. Sandstones and shales, interbedded, greyish and reddish-weathering.....	15	0
4. Grey, soft sandstone and sandy shale.....	15	0
5. Brownish sandstone.....	0	4
6. Grey, soft sandstone.....	5	0
7. Hard, purplish-weathering shale.....	0	4
8. Purplish-grey shale.....	4	6
9. Reddish-brown sandstone.....	0	3
10. Grey shale.....	2	6
11. Grey sandstone.....	2	0
12. Soft, purplish and bluish-grey shale.....	14	0
13. Grey and bluish-grey crumbling shale.....	3	0
14. Hard, grey sandstone.....	4	0
15. Grey, crumbling shale.....	4	0
16. Hard, grey sandstone.....	1	6
17. Soft, greyish sandstone and sandy shales.....	18	0
18. Hard, grey sandstone.....	6	0
19. Greyish and purplish crumbling shales.....	3	0
20. Brownish sandstone and shale with some ironstone...	8	0
21. Grey shaly sandstone.....	8	0
22. Bluish-grey sandstone.....	3	0
23. Grey, sandy clay.....	1	0
24. Irregular arenaceous ironstone.....	0	2
25. Soft clays and sandy clays.....	15	0
26. Brownish-red clay.....	15	00
27. Soft grey and bluish-grey shales with many small irregular calcareous nodules.....	20	00
28. Harder flaggy sandstones and sandy shales. Finely ripple-marked (Current S. 50° E. or N. 50° W.).....	12	00
29. Thinly bedded sandstones and sandy shales.....	15	00
30. Brownish sandstone.....	2	6
31. Soft, grey sandy shales.....	18	00
32. Hard, ripple-marked sandstone.....		4
33. Grey, sandy shales.....	4	0
34. Hard, grey sandstone.....	4	0
35. Greyish and bluish-grey sandy shales and sandstones (partly concealed).....	15	0
36. Calcareous ironstone, traces of fossils.....	1	0

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37. Grey sandstone and sandy shales.....	5	0
38. Brown and grey flaggy sandstones, with fucoidal markings and worm-burrows.....	2	0
39. Greyish and bluish-grey sandy shales and sandstones	10	0
40. Impure ferruginous and arenaceous limestone with fresh-water shells (<i>Bulimus diximetus</i> ? <i>Sphærium</i> , &c.)	0	6
41. Grey, sandy shales	4	0
42. Brown sandstone.....		4
43. Greyish, sandy shales.....	6	0
44. Brown sandstone.....	1	0
45. Bluish-grey, soft sandstones and sandy clays.....	48	0
	<hr/> 341	<hr/> 4

Below the base of the section is about fifty feet in thickness of sandstones and shales of general bluish-grey tints. These, owing to the difficulty of the hill-side, could not be measured. The upper beds, down to about layer 27, may be assumed from their colours and appearance to represent a portion of the Willow Creek subdivision, though indicated at this place. The sandstones, throughout, vary much in regard to induration, some being quite hard, while others are scarcely consolidated. No carbonaceous layers were observed, but abundance of little plates of calcite, like those alluded to on a former page occur in some of the beds. Layer 40 appears to be identical with that seen on the Upper Milk River to the east (p. 37 c), and carries similar fossils. It is the only part of this section in which fossils were observed. The beds at the base of the section dip S. 15° W. < 40°, but the upper layers lie at a much lower angle, and appear to assume a synclinal form.

Down the river from this point, the banks for a distance of two to three miles, appear to be occupied by the St. Mary River beds, but owing to the existence of a wide low flat, a portion of the river-section is concealed. At the lower end of the flat, well characterised Willow Creek beds appear, and occupy the valley for a distance of over seventeen miles northward. They may be described generally as grey and bluish-grey, purplish and reddish beds, chiefly clays and arenaceous clays, forming crumbling banks, but with some sandstones. The horizon appears to be nearly the same throughout, and the whole may be considered, in a broad way, as resting in the southern extension of the Porcupine Hill synclinal; though light undulating local dips render it impossible here to recognise the general structure. No fossils were anywhere observed in these exposures. The banks frequently show a considerable capping of boulder-clay, but the underlying quartzite shingle is not here found.

General
character of
the rocks.

Wide area of
Willow Creek
beds.

Sections of St.
Mary River
beds.

Light westerly or north-westerly dips, however, eventually prevail, and bring the grey, bluish, and yellowish-grey thin-bedded sandstones, sandy shales, and argillites of the typical St. Mary River series, to the surface. Near the top of these, a layer holds *Viviparus*, and other fresh-water shells, badly crushed, with some imperfect plant remains, consisting of fragments of *Physaenia Parlatorii*. In correspondence with the harder character of these beds, the river-valley again becomes cañon-like, and turning north-eastward runs for five miles between banks from one hundred, to one hundred and thirty feet in height presenting continuous exposures of the rocks, which are almost perfectly horizontal, though the slope of the river gradually brings somewhat lower beds to view. At the lower end of this reach, a bed containing the species above alluded to again occurs.

From this point, the general course of the river is nearly due east, for three and a half miles, but the stream is exceedingly tortuous. The banks are somewhat lower and less scarped, but a well-marked wide ridge here impinges on the valley on the north side, and runs thence north-north-eastward toward the Belly Butte. The dips appear generally to be north-westward, at angles less than five degrees. Some scarped banks, eighty feet in height, are composed entirely of boulder-clay to the water-level.

Gooseberry
Canon.

The river here again turns northward, and nearly following the 113th meridian for three and a half miles, is closely hemmed in on both sides by high banks, which are frequently almost vertical cliffs one hundred and fifty feet high, and afford fine sections of the bluish- and yellowish-grey beds of the St. Mary River series. Sandstones here preponderate, and there is a distinct tendency to northerly and even to north-easterly dips, implying a broad lightly-marked anticlinal arrangement of the beds. Crushed fresh-water molluscs occur in several places, and at one point large masses, evidently from the immediate vicinity, were found holding remarkably well-preserved shells, including *Bulimus disjunctus* (?), *Corbicula Nebrascensis*, *Viviparus*, *Goniobasis*, &c. Ripple-marks, denoting currents in a direction S. 50° E. or N. 50° W. were noted at one point.

Sections below
Gooseberry
Canon.

The river in this part of its course, which has been called the Gooseberry Cañon, is almost one continuous rapid, and at one place an actual fall a few feet in height occurs. It is exceedingly dangerous for canoeing even at high water, and is probably quite impracticable at a low stage owing to the great number of boulders in its bed.

The St. Mary River series continues for a further distance of five miles by the course of the valley, which though with lower banks, still yields an excellent section. The direction of dip now changes to southward and south-westward at similar low angles to those before

CAÑON.]

observed, and probably. No marked change in a short distance of observed to become interbedded with of fresh-water moll this horizon. Frag matter becomes rat At the base of th fifty feet in thick natural cliff of its the river was seen the Pierre group, w of *Incoceras* and *L cardium*, were found Fox Hill horizon, a by this report in w

For the remainde Mary displays the Numerous sections Pierre occur, somet bank, to the mount were found in abu marking the base of the water's edge, nin ble dips bring it o about two miles abo base of the section, reached.

In the annexed sec exposure, while the one hundred yards c

Rusty, ironstone l
Blackish and rust
Coal
Blackish shale...
Coal
Soft, carbonaceous
Coal
Soft, thin, shale, h
ceons in upper
Ironstone shale..
Blackish shale...
Coal

observed, and probably in no case, even locally, exceeds ten degrees. No marked change in the character of the rocks was noted till within a short distance of the base of the series, where the sandstones were observed to become yellowish in colour and less massive, and to be interbedded with blackish-grey shales. Poorly preserved specimens of fresh-water molluses, among which *Unio* is conspicuous, occur at this horizon. Fragments of bone were also found, and carbonaceous matter becomes rather prominent.

At the base of the Laramie, a massive sandstone of a grey tint and fifty feet in thickness appears, dipping S. 55° W. < 3°. It forms a natural cliff of its full thickness at one point, and a little further down the river was seen to overlie about thirty feet of blackish clay-shale of the Pierre group, which holds marine fossils. Among these, fragments of *Incoceras* and *Baculites*, with others doubtfully referable to *Protocardium*, were found. The massive sandstone doubtless represents the Fox Hill horizon, and there are few places in the district embraced by this report in which it is so well marked. Fox Hill sandstone.

For the remainder of its course—ten miles in a straight line—the St. Mary displays the rocks of the Pierre group of the Cretaceous only. Numerous sections of the blackish- and bluish-grey clay-shales of the Pierre occur, sometimes with a volume of one hundred feet in a single bank, to the mouth of the river, and the characteristic molluses were found in abundance in several places. The coal-bearing zone marking the base of the Pierre, first appears in a low anticlinal, near the water's edge, nine miles above the mouth of the river. Light variable dips bring it occasionally to view for about three miles, when, at about two miles above the crossing of the trail, it passes below the base of the section, and is not again seen till the mouth of the river is reached. Pierre shales.

In the annexed section, the first column represents the first-mentioned exposure, while the second is a continuation of the first at a spot about one hundred yards down stream :— Coal-bearing zone.

	FEET.	INCHES.		
Rusty, ironstone layer.....	0	8		
Blackish and rusty shale.....	5	0		
Coal	0	3		
Blackish shale.....	6	0		
Coal	0	6		
Soft, carbonaceous shale.....	0	4		
Coal	0	8		
Soft, thin, shale, highly carbonaceous in upper part	0	6		
Ironstone shale.....	0	6		
Blackish shale.....	3	0		
Coal	0	8	Coal.....	1 0

FEET. INCHES.

FEET. INCHES.		FEET. INCHES.	
Carbonaceous shale (some coal).	1 6	Shaly coal.....	6 6
Coal (partly below water).....	1 6	Coal.....	1 3
		Shale.....	0 2
		Coal.....	0 9
		Grey shale.....	4 0
		Coal.....	1 4
		Grey shale (to water)	4 0

About two miles further down the St. Mary, where the coals next appear, they have the following development:—

Coal (rather shaly).....	1 0
Coal	1 4
Shale.....	0 3
Coal	0 9
Shale	10 1
Coal	3 8
Shale (with obscure plant impressions)	6 0

The same horizon, as displayed in the section at the confluence of the St. Mary and Belly, is described in connection with the geology of the latter river.

Boulder-clay.

Though not generally referred to in the foregoing notes, the boulder clay, in greater or less thickness, caps nearly all the river sections and in some places forms entire banks. It was first seen to overlie the shingly quartzite deposit at a point about four miles from the mouth of the river.

Upper Belly River.

Sections near
49th Parallel.

The Upper Belly Valley, for about five miles from the point at which it crosses the 49th parallel, lies between high and more or less densely wooded foot-hills, which form a connection between Chief Mountain and the Mount Wilson Range. Even in the contracted upper part of the valley, however, sections are infrequent, and chiefly display drift material. At about four miles north of the 49th parallel, I examined some beds of thin sandstones and clays, dipping northward at an angle of 15°, which appeared to be Laramie. A short distance further down stream, fragments of lignite were found, which have almost certainly been derived from some bed *in situ* in the upper part of its course.

Region of
flexed beds.

Seven and a half miles north of the 49th parallel, a belt of blackish Cretaceous shales holding *Inocerami*, crosses the river. The shales are well exposed in a small coulée on the west side, and a little further down the river, are found to be interbedded with and overlain by sandstones,

which dip N. 20° E. grey clays and sandstones, a couple of exposures of probable that those beds of the St. M. referred to conform north of the 49th south-western edge beds, the continuous parallel ridges stre but which appear River is reached in point above referred stones and are dou

Two miles further out shales crosses t of 40°. For some shales and sandston River subdivision. of red clay. The Following these, at a bank presents the

1. Yellowish sandstone.
2. Dark shales.
3. Lignitic shales.
4. Lignite
5. Lignitic shales.
6. Grey sandstone.
7. Dark shales.
8. Lignitic shales.
9. Lignite-Coal.
10. Shales
11. Sandstone
12. Shaly sandstone.
13. Dark shales.
14. Coal (of good quality).
15. Dark shales.

The last-noted shales and may possibly be so frequent in the district, however, t

which dip N. 20° E. < 10°. Half a mile further down the river, greenish-grey clays and sandstones with a dip of N. 20° E. < 15°, are found in a couple of exposures. One reddish zone of beds was seen, but it is scarcely probable that these represent the Willow Creek series. They are likely beds of the St. Mary River subdivision, and follow the shales above referred to conformably. Where the rocks are again seen, eleven miles north of the 49th parallel, they dip S. 30° W. < 65°, and mark the south-western edge of a wide belt of crumpled, disturbed and overturned beds, the continuation of which to the south-eastward is shown by parallel ridges stretching towards Lee's Creek and the St. Mary River, but which appears to subside to a great extent before the Waterton River is reached in the opposite direction. The beds consist, at the point above referred to, of greenish shales, with yellowish-grey sandstones and are doubtless of the St. Mary River subdivision.

Two miles further northward, a second band of dark, sandy Cretaceous shales crosses the river, with the same direction of dip, and an angle of 40°. For some miles northward the only rocks seen are interbedded shales and sandstones resembling, on the whole, those of the St. Mary River subdivision. One thin bed of lignitic shale was observed, and one of red clay. The dips are S. 20° to 40° W. at angles of 15° to 20°. Following these, at a point seventeen miles north of the 49th parallel, a bank presents the subjoined section:—

	FEET.	INCHES.	Section with their coals.
1. Yellowish sandstone	1	6	
2. Dark shales	3	0	
3. Lignitic shales	1	0	
4. Lignite	0	6	
5. Lignitic shales	1	0	
6. Grey sandstone	6	0	
7. Dark shales	0	6	
8. Lignitic shales	1	5	
9. Lignite-Coal	1	2	
10. Shales	4	0	
11. Sandstone	1	0	
12. Shaly sandstone	5	0	
13. Dark shales	10	0	
14. Coal (of good quality)	1	0	
15. Dark shales	60	0	
	97	1	

The last-noted shales much resemble those of the Cretaceous (Pierre) and may possibly belong to that system. Sandstone intercalations are so frequent and considerable in the Cretaceous shales of this district, however, that without a very great amount of work, and the

Disturbed
character of
strata.

discovery of many additional fossil-bearing localities, the complete separation of the Cretaceous and Laramie cannot be carried out.

Half a mile further down stream, a sharp synclinal which, however is evidently of a local character, occurs. The lowest bed seen is a coarse massive sandstone fifty feet thick. It is followed by fifty feet of blackish shales resembling those of the Pierre, but holding Laramie fossils, and containing an oyster-bed of five feet in thickness. This is followed by about seventy-five feet of grey sandstones with lignite and shales of the usual character. Next follows about 200 feet of alternating sandstones and shales, then about fifty feet of soft greenish-grey argillaceous sandstone, alternating with hard reddish-brown sandstone in beds a foot thick; and then a thick series of greyish and reddish sandstones and greenish-grey shales, which hold a second oyster-bed about seven feet thick, and a thin bed of conglomerate, the pebbles of which are chiefly composed of Rocky Mountain limestone. The latter is an unusual feature, but clearly indicates the proximity of the beds in this region to the Palaeozoic shore-line.

Limestone
conglomerate.

Less than a mile further down the river, about 200 feet of blackish Cretaceous shales appear, evidently lower in the series than the last, with a dip of S. 30° W. < 30°. Interstratified with the shales are a number of sandstones about six inches in thickness, and one massive bed twenty feet thick. Overlying the shales in this section about one hundred and seventy-five feet thick of greyish and brownish sandstone occurs, which at one point, where the attitude is nearly vertical becomes almost a quartzite. The sandstone includes an oyster-bed about three feet thick, and a second layer contains other marine shells, in association with some lignitic shales.

Fossiliferous
beds.

The oyster-beds, besides *Ostrea* hold *Corbicula occidentalis* and other shells and evidently correspond with those seen at Rye-grass flat on the Old Man, and mark the passage from the marine conditions of the Pierre to the fresh-water fauna of the Laramie.

For about three miles down the river from the point last described, exposures are not infrequent, and show rocks—chiefly sandstones—which contain *Ostrea glabra*, var. *Wyomingensis*, *Corbicula occidentalis*, *Cypriiformis*, *Melania Wyomingensis* (?), &c., and resemble those above referred to as overlying the Pierre. A distinct anticlinal axis here, however, crosses the river, with a north-west and south-east strike, and the attitude of the beds would seem to indicate that they underlie the dark Cretaceous shales. The angles of dip are, however, very inconstant, and unobserved flexures, or possibly faults, may account for this appearance.

The south-western edge of the wide area of Willow Creek beds which occupies the southern extension of the Porcupine Hill synclinal, is sup-

posed to cross the river, and occur in the hills a few miles. Where the beds consist of the Belly Butte formation, the junction with the Pierre is especially from the river, but high, and are entirely covered by the division. The beds appear to be calcareous nodules of calcite in places, strewn the observed.

Drift
Reddish clay .
Coarse, grey sandstone
Dull red sandstone
Grey sand
Hard, grey sandstone
Grey sand
Dull red clay .
Bright red clay
Grey sand
Yellowish clay
Grey arenaceous
Dull red clay .
Grey sands and
Yellowish, reddish
Grey sandstone
Greyish sands . .
Yellowish, reddish
Arenaceous clay
Reddish and grey
Nodular bed . . .
Red and grey clay
Yellowish, reddish
Grey sand
Yellowish clay .
Grey sandstone
Grey clays
Reddish and grey
Grey sands and
Reddish and grey

posed to cross the river three miles below this point, but no exposures Belly Butte occur in the banks to the mouth of the Waterton—a distance of twenty miles. Where scarped banks are found, they show only drift deposits, consisting for the most part of silty material containing a few boulders.

The Belly Butte, which stands on the east side of the river near its junction with the Waterton, is a conspicuous feature and land-mark, especially from the west. The most elevated point lies back from the river, but high, scarped hillsides border the river-valley itself and these are entirely composed of beds referable to the Willow Creek subdivision. The following section was measured here by Mr. R. G. McConnell, and gives a good idea of the rocks composing this series. The beds appear to have a light south-westward dip. Small reniform calcareous nodules abound throughout the series, and together with flakes of calcite, similar to these previously referred to in several places, strew the surfaces of its weathered banks. No fossils were observed.

	FEET.	Section of Willow Creek beds.
Drift	20	
Reddish clay	1	
Course, grey sand	4	
Dull red sand	4	
Grey sand	3	
Hard, grey sandstone	2	
Grey sand	12	
Dull red clay	5	
Bright red clay	2	
Grey sand	1	
Yellowish clay	5	
Grey arenaceous clay	2	
Dull red clay	3	
Grey sands and sandstone	5	
Yellowish, reddish and greyish clays	20	
Grey sandstone	1	
Greyish sands	6	
Yellowish, reddish and greyish clays	12	
Arenaceous clays (nodular beds)	4	
Reddish and greyish clays	4	
Nodular bed	1	
Red and grey clay	10	
Yellowish, reddish and greyish clays, containing calcareous nodules	20	
Grey sand	2	
Yellowish clay	3	
Grey sandstone	1	
Grey clays	35	
Reddish and greyish clays	6	
Grey sands and sandstone	6	
Reddish and greyish clays	15	
	214	

At two points between the Belly Butte and crossing-place of the trail to MacLeod, exposures were seen showing grey and yellowish, soft sandstones, and dark-greenish or greyish and brownish clays. At one of these several specimens of *Unio* were collected. About a mile and a half below the trail-crossing, on the east bank, another exposure occurs, in which a massive yellowish-weathering sandstone, thirty feet thick, overlies greenish-grey shales, with lignitic shales and thinly-bedded sandstones. A few fossils were obtained. From this point to the confluence of the Old Man River, no sections were found, though the whole thickness of the St. Mary River beds, and a considerable portion of the upper part of the Pierre shales, must cross this part of the valley.

Waterton River.

Rocks near
Waterton
Lake.

The country about the lower or northern of the Waterton Lakes, from which the river of the same name issues, consists of low rolling hills, largely composed of morainic material, and no exposures of the underlying rocks occur. It is, however, from analogy supposed to be underlain by Cretaceous or Laramie strata. The first section examined near the Waterton River, is found on the brook which joins it nearly two miles below the lake. The rocks are very dark blackish-grey shales or sandy shales, and are somewhat irregular in attitude, those furthest down the brook dipping S. 18 E. $< 35^\circ$, while less than a quarter of a mile distant, where seen furthest up the stream, they dip S. 25 W. $< 30^\circ$ – 40° . The thickness exposed is at least one hundred feet. Layers of calcareous or ferruginous concretions occur, with some large *Inocerami*, one of which where cut across in the bank measured two feet in diameter, with a maximum thickness of an inch and three quarters. A specimen collected here appears to be *I. Umbo-natus*, and is covered with valves of *Ostrea congesta*.

This band of Cretaceous shales does not appear to be continuous with any of those seen on the Upper Belly, and has not been traced further.

Sections on
upper part of
river.

Between this point and the mouth of the North Fork of the Waterton, a ridge nearly three miles long occurs on the opposite, or east side of the river. On the summit of the southern end of this ridge, there are considerable exposures of brownish and grey sandstone composed of hard and soft layers interbedded, of which in all about thirty feet in thickness is seen. The dip is N. 48° E. $< 5^\circ$, and a small but unmistakable fragment of *Inoceramus* was found in one of the beds. East of the northern end of the ridge, on the river, bluish-grey beds, chiefly sandstone, were observed, with a dip N. 45° E. $< 30^\circ$. About a mile up the North Fork from the river, where the valley becomes cañon-

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like, rocks resembling the last again occur, with a dip N. 10° E. $< 25^{\circ}$. Taken in conjunction with the sections on the Upper Belly, it is probable that the sandstones of the south end of the ridge belong to an upper part of the Cretaceous, and that those of the north end and on the North Fork represent the lower part of the St. Mary River series. The belt of dark Cretaceous shales which appears on the Upper Belly about seven miles north of the 49th parallel, must lie immediately below the above-mentioned Cretaceous sandstones, and the strike of the beds would carry them through to the exposures of similar shales seen on the Drywood Fork nine miles west of the Waterton. No sections, however, occur on the North Fork where they might be expected to cross. The shales probably mark an anticlinal axis, and it is uncertain whether the overlying sandstones have been removed to a sufficient depth to expose them throughout the entire distance above indicated.

On the next westward bend of the Waterton, below the mouth of the North Fork, beds with the character of those of the Willow Creek subdivision appear, with a dip of N. 53° E. $< 30^{\circ}$. These doubtless occupy the trough of a synclinal, to the north of the anticlinal last described. The return or south-westward dip of those beds was not observed, but the centre of the synclinal is probably marked by a copious spring in the north bank of a wide depression about a mile further on.

From the last-mentioned exposure, the rocks were not again seen in the river-valley for some distance, till, immediately opposite a prominent rocky ridge which is situated about a mile and a half east of the river, large yellowish sandstone blocks indicate the outcrop of a bed of the same material. The crest of the ridge, which is bare and scarped, consists of rather hard flaggy sandstones, sometimes considerably charged with ferrous carbonate, and characteristically brown in colour, with a dip of S. 18° W. and very regular. The ridge is about half a mile long, and appears to form a north-western outlier of one which, commencing on the east side of the Upper Belly, runs across almost to the St. Mary River. It forms the north-eastern edge of the synclinal above described, and is probably near the base of the Laramie or at the top of the Cretaceous, as in a coulée some distance to the southward, extensive exposures of the generally bluish-grey beds of the typical St. Mary River series occur overlying it, with a similar strike and dip. The beds in the continuation of the ridge east of the Upper Belly, however, show an opposite dip, and are probably locally overturned.

To the mouth of the Drywood Fork, and for a mile further, no additional opportunities occur for an examination of the rocks. Thence for nearly four miles the valley was not examined. The rocks next observed were those of the St. Mary River series, at first rather dis-

Cretaceous
shales.

Small synclinal.

Little Rocky
ridge.

St. Mary River
and Willow
Creek beds.

turbed by several undulations, and with a general tendency to a south-westward dip, which was at one place observed at an angle of nearly 60°. The rocks then turn over an anticlinal axis, and half a mile further north dip at an angle of 50° in the opposite direction, or N. 20° E. At this point, the stream makes a rather remarkable flexure to the westward between high cliffs, and then changes its general direction to north-east, entering, in about a mile, the wide area of Willow Creek beds. These beds continue to characterize it to its mouth.

At the bend of the river above alluded to, the circumstances appearing favourable, an attempt to measure the thickness of the beds was made, with the following result:—

Measurement of part of Laramie.		FEET.
	1. <i>St. Mary River beds</i> .—Exposures near the axis of the anticlinal, not continuous, but with general north-easterly dips (estimated).....	500
	2. <i>St. Mary River beds</i> , measured by pacing and triangulation (actually seen).....	640
	3. <i>St. Mary River and Willow Creek beds</i> .—Interval between the highest beds of last, and first seen of Willow Creek beds, at assumed minimum dip, least thickness.....	1,680
	4. <i>Willow Creek beds</i> .—Thickness actually seen (estimated) ...	450
	Total thickness of part of Laramie series.....	3,270

The above section is in ascending order, and differs in this respect from others in the report. By deducting the observed thickness of Willow Creek beds, an approximate thickness of 2,800 feet is obtained for the *St. Mary River beds*. This may include a portion of the Willow Creek beds at the top, but the base of the *St. Mary River* subdivision was not attained.

Willow Creek
beds.

The Willow Creek beds first appear with a north-eastward dip at an angle of 30°, which flattens out a short distance further down the river, and is then followed by light (under 5°) westward and south-westward dips, alternating with sections in which the beds appear to be perfectly horizontal, and these conditions continue to the confluence with the Upper Belly. The rocks are of the character usually met with in this subdivision when unaffected by flexure and concurrent induration. They consist of reddish, purplish and brownish, hard crumbling clays, in which small reniform calcareous nodules are frequently found, and soft, generally grey, sandstones, which are often rather massive and without evident traces of bedding. Crushed fresh-water shells were observed in one locality. The length, without counting its flexures, of that part of the Waterton River flowing across these rocks, is eighteen miles.

SEC

The rocks of its tributaries, of special interest. The subdivisions of synclinal. East Belly is one of is fully described.

The first seen water's edge, of thence for a distance frequent exposures. The beds consist of pale clays, with soft bedding is uniform, which cause forms. In some reniform, and generally similar appearance where, and are possibly be phosphatic. The beds are low Creek beds, with exception of the verted into ironstone. estimate of the thickness of one section a thickness shown.

At the north observed, and the There is no reason difference in color and the line of section justified by the flexure in the extreme beds here immediately have general brown and show persistence sandy and shaly and sometimes show a remarkably regular

SECTION ON THE OLD MAN AND BELLY RIVERS.

The rocks east of the disturbed foot-hill belt, on the Old Man and its tributaries, have been examined in a few places, but possess no special interest. They consist of the Willow Creek and Porcupine Hill sub-divisions of the Laramie and form part of the wide Porcupine Hill synclinal. East of Fort MacLeod the section on the Old Man and Belly is one of the most interesting and important in the district, and is fully described below.

The first scarped bank below Fort MacLeod is composed, to the water's edge, of drift clays, but at the mouth of Willow Creek, and thence for a distance of about four and a half miles down stream, frequent exposures occur of the Willow Creek sub-division of the Laramie. The beds are to all appearance horizontal or very nearly so, and consist of pale purplish, reddish, and greenish-grey clays or sandy clays, with soft sandstones and occasional bands of ironstone. The bedding is uniform and regular, and the whole series has a soft character, which causes it in some places to weather into miniature bad-land forms. In some clayey layers, peculiar whitish-weathering irregularly reniform, and generally small sized concretions, abound. Nodules of similar appearance frequently occur in the beds of this horizon elsewhere, and are rather characteristic. It was supposed that they might possibly be phosphatic, but they proved on chemical examination, to be merely calcareous. Organic remains are usually rare in the Willow Creek beds, and in these exposures none were observed, with the exception of the scattered fragments of a single large Chelonian, converted into ironstone. Owing to their nearly horizontal position, no estimate of the total volume of these beds can be made here, but in one section a thickness of one hundred and forty feet is actually shown.

At the north bend of the Old Man River, a light westerly dip is observed, and the older beds of the St. Mary River sub-division appear. There is no reason for the separation of this from the above series, but difference in colour, and to some extent in the composition of the beds, and the line of separation is in consequence only an approximate one, justified by the facility which it affords of recognizing a definite horizon in the extremely thick Laramie formation of this district. The beds here immediately below those of the Willow Creek series, have general brownish colours, but soon become more varied in aspect, and show persistent greyish and greenish-grey tints. They consist of sandy and shaly clays and shales, interbedded with sandstones, which sometimes show ripple-markings, and of which the bedding is often remarkably regular. The sandstones are often quite hard, and project in

Rocks near
Fort MacLeod.

Nodules

Junction
Willow Creek
and St. Mary
River beds.St. Mary River
series.

Fossils.

cornice-like forms from the bank. Ironstones also occur in nodules and layers, one of the latter being observed to be as much as 2 feet 6 inches in thickness. These beds are less massive and alternate more rapidly than those of the overlying series. They characterize the river for about eight miles, following its course, or to Rye-grass flat, and are affected by light undulating dips which seldom exceed ten degrees in amount. At least 200 feet in thickness of beds of this character are exposed, but no precise estimate of their total thickness could be made. They were found to contain in several places fresh-water molluscs, among which the following species are represented:—*Goniobasis* like *G. Nebraskaensis*? *Cassiopella* n. sp., *Viviparus Leai*, *Sphærium* n. sp., *Hyalina* or *Valvata*, *Acroloxus*, *Slenites*. They also hold a few obscure impressions of plants.

Upturned beds at Rye-grass flat.

Opposite Rye-grass flat, after an interval of nearly a mile without exposures, a small low point shows brownish and yellowish earthy sandstone, with a southwestward dip at an angle of 45°, and holding remains of *Ostrea*. This is followed on the same side of the river by a scarped bank composed of similar rocks, with about the same dip. Facing this, at the lower end of the wide flat, the same rocks are again well shown, and dip westward at angles of 40 to 45 degrees. These

Brackish-water fauna.

rocks are evidently of brackish-water or estuarine character throughout, and hold abundantly *Corbula*, n. sp. like *C. pyriformis*, with a large form of *Corbicula occidentalis* and valves of *Ostrea*.

Some layers are almost composed of these shells in densely crowded and occasionally hard masses, but the rocks are as a rule quite soft in character, and may be described as sandstones and sandy clays of yellowish and brownish colours, with occasional carbonaceous shades. The total thickness of the brackish-water beds here, was not ascertained, but it must be very great, as the portion which could actually be measured, on the left bank, is about 840 feet thick. Occasional coaly streaks, apparently produced by compressed masses of drift wood, are found in the sandstones. The fauna is that characteristic of the transition beds between the Fox Hill series and the generally fresh-water Laramie above, but the Fox Hill sandstones themselves were not here clearly recognized, though at a distance of about twenty-one miles only, on the St. Mary River, they form a massive layer about eighty feet in thickness. The beds of Rye-grass flat, with similar appearance and molluscous fauna, re-appear at Scabby Butte a few miles to the north (page 79 c).

Fox Hill sandstones.

There is no apparent reason for the sudden interruption at this spot of the generally low dips, or nearly horizontal attitude, which the rocks elsewhere maintain east of the disturbed foot-hill belt, within the limit covered by the present report. On the east side of the

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point below the flat, these rocks still continue, but are somewhat irregularly folded and broken and in places become almost flat. They are seen to be followed in descending order by coffee-coloured clay shales, very regularly stratified, in beds each of which is a few inches in thickness. These constitute the upper part of the Pierre shales, and have at this place a thickness of about fifty feet. The beds now again become quite regular, and are to the eye horizontal, or affected by very light low undulating dips. Just below the point at which the Old Man enters the Belly River, the Pierre becomes well characterized, with its distinctive blackish clay-shales, and these continue thence to the mouth of the St. Mary River, a distance of twelve miles. Numerous specimens of *Cyprina ovata* var., with fragments of *Baculites* and *Ammonoites* were obtained from this part of the Pierre. From about two miles above the mouth of the Belly River and thence to the St. Mary, the drift deposits are remarkably thick, a circumstance doubtless due to the great depth to which the surface of the Pierre shales had been worn away, in consequence of their soft character.

The base of the Pierre shales is reached at the mouth of the St. Mary River, and the angle between the two rivers to the east, shows, in a scarped bank, the greyish and yellowish-grey shales and sandstones of the next sub-division of the Cretaceous in descending order, with the associated coal, which is considered as forming the base of the Pierre group. The section in this bank, as measured by Mr. McConnell, is as follows, the order being descending:—

	FEET. INCHES.	
1. Dark shales	0	6
2. Ironstone	2	0
3. Brownish, shaly sandstone	3	0
4. Finely laminated dark shales	2	6
5. Oyster bed	0	10
6. <i>Coal</i>	0	9
7. Carbonaceous shales	9	0
8. Laminated dark shales	0	9
9. <i>Coal</i>	0	9
10. Carbonaceous shales	10	0
11. Laminated dark shales	1	1
12. Carbonaceous shales	3	6
13. <i>Coal</i> (3 ft. to 3 ft. 6 in.)	3	0
14. Carbonaceous shales	2	0
15. Laminated dark shales	30	0
16. Yellowish-weathering sandy shales	5	0
17. (Concealed)	3	0
18. Lignitic shales	6	0
19. Laminated dark shales	3	0
20. Brownish sandstone	1	2
21. Hard, greyish sandstone, topped with ironstone	5	0
22. Lignitic shales	15	0
23. (Concealed)	25	0
24. Soft, greyish and yellowish sandstone		

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St. Mary River
to Coal Banks.

Rocks of Belly
River series.

Rocks of
Coal Banks.

Outcrop of
coal seams.

From the mouth of the St. Mary, the Belly runs three miles eastward, and then turning sharply at right angles flows northward for about the same distance to the point known as "Coal Banks" or the "Colliery." This part of the river-valley is entirely excavated in the sub-Pierre rocks, a portion of the upper part of which has just been described, and which, from the fine sections which occur here and at other points further down the river, I have designated in a previous report as the Belly River series. The rocks of the Belly River series, though at first sight resembling those of parts of the Laramie, and particularly that portion of it which has been described as the St. Mary River sub-division, are found, on closer examination, to differ considerably in the more massive and irregular character of the beds, and their generally softer and more earthy condition. There is a marked absence of the regular and often flaggy sandstones which occur so frequently in the younger series, the sandstones of the Belly River sub-division being generally thicker, and almost always more irregularly hardened, while ironstone is much more abundant and occurs in larger masses. The scarped banks of the river in this part of its course, are cut by numerous deep ravines or coulees, and frequently show badland weathering. In colour the beds are generally greyish, or yellowish- or greenish-grey, but nearly always quite pale in tint. The ironstone nodules are often very large in the sections now described, and generally septarian, the internal fissures being filled with calcite, or lined with that mineral in rhombohedral crystals. The only organic traces here met with were fragments of bones, doubtless reptilian, but so much broken as to yield very little information. In many cases the bones appear to have been rounded and water-worn before their inclusion. The beds are to all appearance flat, and the thickness exposed in the banks is about 200 feet.

At the point known as Coal Banks, the outcrop of the coal marking the base of the Pierre shales, which has run northward west of the river, again appears on the left bank. From this point to Big Island,—a distance of twelve miles in a direct line,—the river, though with numerous minor flexures, pursues a general north-north-eastward course, and nearly follows the outcrop of the coal-bearing horizon and base of the Pierre. The line of outcrop is, however, somewhat sinuous in outline. It crosses the river just north of Coal Banks, and making a sweep, the exact outline of which is uncertain owing to the thickness of the drift deposits which here form the whole surface of the country, recrosses the river to the left or west bank, about six miles above Big Island. Thence, owing to the slight divergence of the line of strike and main course of the river-valley, the coal-bearing horizon may be observed gradually rising in the bank, till it is eventually cut off by the base of

[LARAMIE]

the drift deposits. In consequence of the base of the nearly five miles entirely occupied by the drift, the bottom of the probably not of exposures, B of the coal seam reached with the definition of the importance.

The Belly V and Big Island of nearly a mile the plain to the fore, cuts into and, with its of these.

Having thus coal on this part on the outcrops the seam.*

The coal-bearing one of these is is that opened in the North-right bank of the as the "main seam."

At Sheran's mouth along the natural level was begun scarped bank from end of the bank in water at the north and associated upward to the base

*In the preliminary given. These were for has since carried out a section with the work

the drift deposits near Big Island, and is not again seen on the river. In consequence of the above described eastern sinuosity of the outcrop of the base of the Pierre, a portion of the Belly Valley extending nearly five miles northward from the coal crops near Coal Banks, is entirely occupied by the Pierre shales. The light undulating character of the dips renders it impossible to estimate the exact depth below the bottom of the valley at which the coal would be found, but it is ^{Depth of coal seam north of Coal Banks} probably not over 500 feet midway between the northern and southern exposures. Besides the obvious method of working the visible outcrops of the coal seam on this part of the Belly River, it might thus also be reached with facility by shafts in the concealed interval, and the exact definition of the attitude of the beds becomes a matter of considerable importance.

The Belly Valley, in that part of its course between Coal Banks and Big Island, is about 300 feet in depth, with an average width ^{Section in Belly Valley.} of nearly a mile, while the drift deposits underlie the surface of the plain to a depth of about 100 feet. The river-valley, therefore, cuts into the Cretaceous rocks to a depth of about 200 feet, and, with its ramifying coulées, presents remarkably fine sections of these.

Having thus briefly described the general mode of occurrence of the coal on this part of the Belly River, the following more detailed notes ^{Details of coal seam.} on the outcrops which occur will serve to show the actual character of the seam.*

The coal-bearing horizon embraces several associated seams, but only one of these is here of sufficient thickness to be worked. This, which is that opened at Coal Banks in "Sheran's mine," and subsequently in the North-Western Coal Company's mine, on the opposite or right bank of the river, may, for the sake of clearness, be referred to as the "main seam."

At Sheran's mine, the coal has been extracted chiefly by quarrying along the natural outcrop, though during the summer of 1882 a small level was begun. The outcrop is situated in the front of a steep ^{Character and position of seam at Coal Banks.} scarped bank facing the river, and the seam, which at the southern end of the bank is about thirty feet above the water, dips away below the water at the northern. The following section shows the mode of occurrence and association of the coal in the bank, but does not extend upward to the base of the drift deposits:—

*In the preliminary report on this district, proximate analyses of this and other coals were given. These were for the most part made by myself, and are not here repeated, as Mr. Hoffmann has since carried out a more complete series of analyses, which are reported on by him in connection with the work of the laboratory.

		FEET, INCHES.	
	1. Finely laminated grey shale	8	0
	2. <i>Coal</i> (shaly below)	1	6
	3. Grey, thin-bedded shale	12	0
	4. Ironstone	0	3
	5. Grey shale	1	9
	6. <i>Coal</i>	0	8
	7. Grey shale and nodular sandstone, carbonaceous below	7	0
Main seam. {	8. <i>Coal</i>	1	4
	9. Shaly parting (often almost absent)	0	4
	10. <i>Coal</i>	4	0
	11. Carbonaceous shale	2	0
	12. Grey shale	2	0
	13. Ironstone	0	4
	14. Greyish and brownish shale	3	0
	15. Carbonaceous shale	3	0
	16. Coaly shale	0	8
	17. Grey shale	2	0
	18. <i>Coal</i>	0	4
	19. Carbonaceous shale (to water)	1	4

The dip at this place is about N. 60° W. (N. 83° W. mag., variation 22° 46' E.), at an angle of five to eight degrees.

On the opposite side of the river, at its next bend, the coal seam is again well shown. It is slightly undulating, and dips gradually away below the water-level at the northern end of the bank. It is near this point that the N. W. C. Company's mine has since been opened. This consists of a level run in on the strike, and is already well situated for a large output. The part of the section designated above as the main seam is here as follows:—

	FEET, INCHES.	
<i>Coal</i>	1	6
Shaly parting (1 to 3 inches)	0	2
<i>Coal</i>	3	3
Total coal	4	9

About four inches in thickness at the base of the seam is here laminated in texture, but appears nevertheless to be of good quality. The general dip is about N. 27° W., at an angle of less than five degrees.

Comparative
sections of
seam between
Coal Banks and
Big Island.

From this point, for a distance of five miles down the valley, as above stated, the dark shales overlying the coal are alone seen. When the main seam again appears, on the west bank of the river, it shows the following section:—

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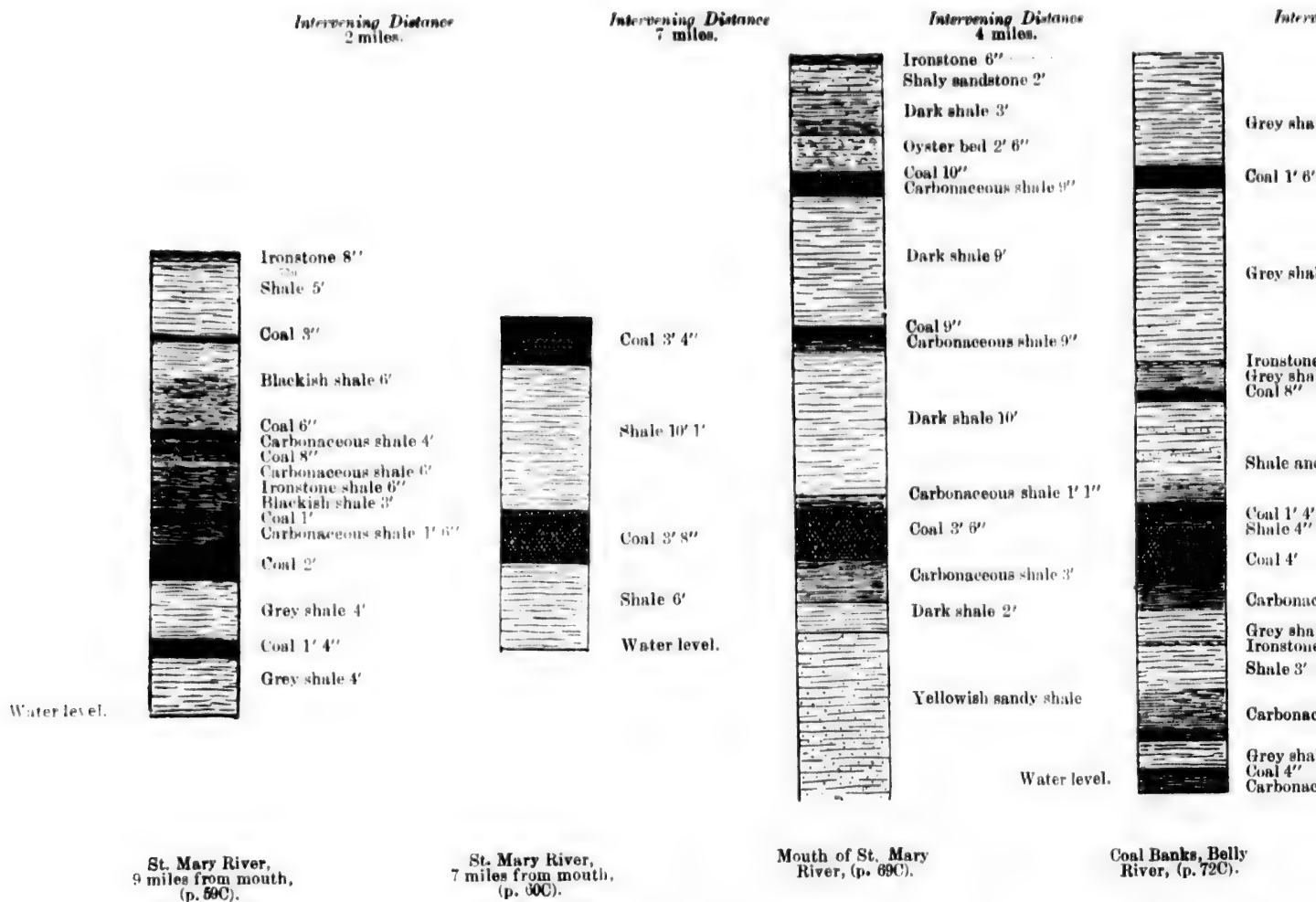
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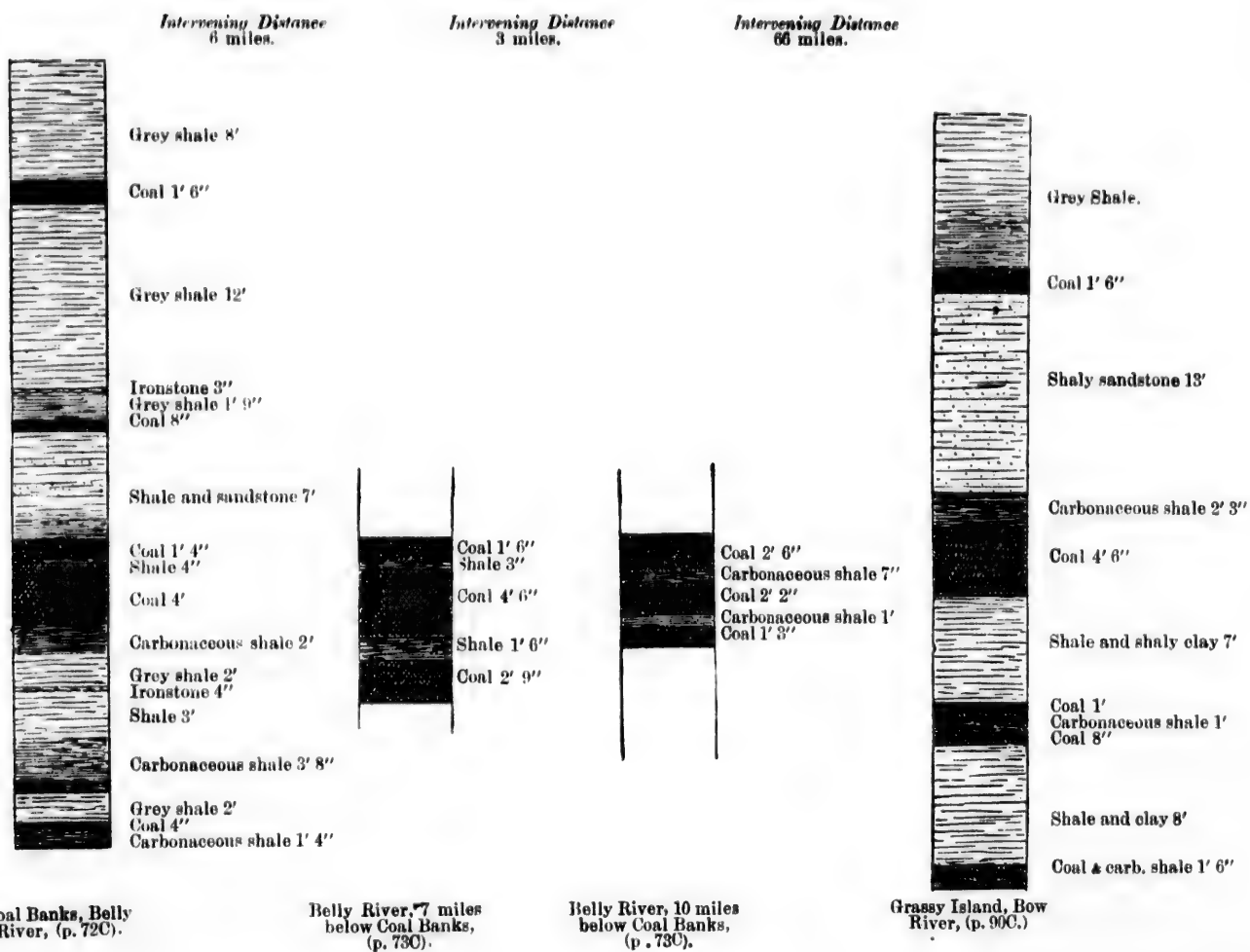
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Coal Bank
River, (p

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COMPARATIVE SECTIONS OF THE COAL-BEARING ZONE AT THE BASE OF THE PIERRE SHALES, REPRESENTED BY THE ABOVE SECTIONS.



E SHALES, REPRESENTING DIFFERENT POINTS ALONG ITS OUTCROP FOR A LENGTH OF 88 MILES.

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	FEET. INCHES.	
<i>Coal</i>	1	6
<i>Shale</i>	0	3
<i>Coal</i>	4	6
<i>Shale</i>	1	6
<i>Coal</i>	2	9
Total coal	8	9

The lowest division of the seam at this place, is apparently not represented in the sections previously described. The coal in it is somewhat laminated, but seems to be of good quality. The dip is here about N. 57° W. at an angle of five degrees.

About three miles further north, extensive exposures of the coal are again found in the scarped bank or cliff facing the river, at a height of about one hundred feet above the water-level, the lower part of the bank being composed of the greyish and greenish-grey beds of the Belly River series. The dip is light and undulating, but on the whole westward, or away from the river. The main seam is here composed as follows:—

	FEET. INCHES.	
<i>Coal</i>	2	6
<i>Carbonaceous shale</i>	0	7
<i>Coal</i>	2	2
<i>Carbonaceous shale</i>	1	0
<i>Coal</i>	1	3
Total coal	5	11

The coal here appears to be of good quality throughout.

North of this point, the coal-bearing horizon is not again found well exposed on the river, the outcrop running to the west of the valley. Opposite the lower end of Big Island, the drift deposits have a thickness of one hundred and sixty-five feet, and below them two coal-seams of a few inches each are seen. These occupy a horizon a little below the main seam, and have a gentle dip westward or away from the river.

Big Island.
Coal outcrop
leaves the
valley.

At Big Island, the river resumes its eastward course, and the scarped banks continue for a distance of four and a half miles, in a direct line, to show fine exposures of the series underlying the Pierre. The banks generally show a thickness of about one hundred feet of these beds, which appear to be practically horizontal. At the first bend to the south beyond Big Island, a hard sandstone layer about fifty feet above the water, and in some layers charged with little greenish-grey rolled pellets of shaly clay, was observed to show also numerous casts of a large *Uro*, with rounded fragments of bone. The inclusion of rounded pieces of the nearly contemporaneous clays in the sandstones is else-

Exposures of
Belly River
series.

Dinosaurian
remains.

Gap in section.

Massive
sandstones.

Rocks from
Little Bow
eastward.

Coal-bearing
horizon.

where found to be rather characteristic of the upper or pale part of the Belly River series, and taken in connection with the irregular bedding and scattered and broken character of the larger bones, would seem to show that the sheet of water in which the beds were laid down was a somewhat turbulent one. At this place a detached tooth was also collected, which Prof. Cope has been so kind as to examine, and pronounces to be that of a carnivorous Dinosaurian, which as it comes from below the Pierre shales may be a *Laelaps*, though it looks much like *Aublysodon* of the Laramie. At the next bend to the north, the scarped banks of the river are 275 feet in height. The upper one hundred feet consists of drift deposits, elsewhere described. Below there is a yellowish sandstone about twenty feet thick, irregularly hardened. This is followed to the water's edge by a series of bluish grey and greenish-grey clays and sandy beds, which occasionally become hard sandstones. Below this point a gap of about a mile and a half occurs in the section on the river, in which a few scarped banks show boulder-clay only, to the water's edge.

The next rocks seen occur at about six miles above the mouth of the Little Bow River, and are supposed to represent the summit of the lower or yellowish portion of the Belly River series. A rather massive yellowish sandstone here appears on the north bank. It forms a low cliff twenty to thirty feet high, at the edge of the water, and is overlain by greyish and yellowish sandy clays holding some selenite. Similar rocks, and apparently on almost exactly the same horizon, are seen in several places between this point and the Little Bow, the sections being, however, generally near the water's edge, and capped by a heavy covering of drift deposits. Coaly layers now begin to appear in the rocks in some places.

From the mouth of the Little Bow to the confluence of the Belly and Bow, rocks similar in general character to those last mentioned, and probably not far from the same horizon, continue to appear in numerous exposures. At seven and a half miles below the Little Bow, a well defined coal-seam, about eighteen inches in thickness, was first observed. It is here at a height of about twenty feet above the river. The sections not being absolutely continuous, and the character of the beds somewhat variable, it was impossible to arrive at certainty as to the equivalency of the beds, but it is probable that the coal-seam just mentioned is that which characterizes the banks nearly to the mouth of the river. It appears at a height above the river-level which varies in accordance with the light dips by which the beds are affected. The rocks associated with the coal are yellowish, brownish and grey, soft sandstones and shales, with occasional layers of ironstone. They show numerous alternations of colour, and produce a generally banded

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appearance in the banks when viewed from a distance. Near the coal-seam, and both above and below it, are several carbonaceous shales, which, however, are not very constant. The greatest thickness of beds of the character just described, seen below the coal-seam, was about one hundred feet. Some beds on this part of the river yield fresh- and brackish-water molluscs in great abundance, the following being among the most characteristic forms:—*Corbula subtrigonalis*, *Corbula perundata*, *Corbicula Nebrascensis*? *Velatella baptista*? *Cassiopella* n. sp. *Campeloma* like *C. producta*; also species of the genera *Goniobasis*, *Viciparus*, *Physa*, *Unio* and *Sphaerium*, as yet undetermined. From the close resemblance, lithologically and in fauna and accompaniments, of the beds in the vicinity of the coal in these sections on the Lower Belly, with those seen on the Milk River north of the East Butte (p. 44 c.), and again in 1874 nearer to the Butte.* I am inclined to suppose the almost absolute identity in horizon of the strata in these localities.

At a mile and three-quarters below the point above referred to at which the coal was first recognized as a well-defined seam, it is found at a height of fifty feet above the river, still maintaining a thickness of about eighteen inches. Its greater height above the river is owing to a light northerly dip by which the measures are here affected, and in following the river in its next great bend to the south, at a further distance of about two miles, the coal is about one hundred feet up in the bank. Two miles further on, it is again seen on the opposite or right bank at a similar elevation.

From this point, the river turns abruptly north, making a great loop which may be called Drift-wood bend. Following this reach of the river to the north, in about a mile and three-quarters, the coal-seam comes down to the water's edge. It is here associated with yellowish sandstone, and has a thickness of three feet three inches. The seam here appears to be of good quality throughout, and this is the most favourable locality observed for working it. The coal contains 9·18 of hygroscopic water only, and is a very fair fuel. (See p. 26 m.)

The coal, for several miles to the north, undulates at low angles from the water's edge to about twenty feet above it. It varies in thickness from the maximum just given to about eighteen inches, and is again seen with the latter dimensions at the north-western point of Drift-wood bend. This coal was not again observed in anything like workable thickness on the Belly, and, indeed, from this point to near the mouth of the river, the sections of the Cretaceous rocks are comparatively inconsiderable, the banks being more rounded, and

*Geology and Resources of the 49th Parallel, p. 122.

the greater part of the depth of the valley being excavated in drift deposits, which here show interesting peculiarities elsewhere described.

Belly River
series near
confluence with
Bow River.

A fine display of the beds of this series is, however, again found about the confluence of the Bow and Belly. At the first south bend on the Belly above the confluence, the following general section was examined:—

	FEET. INCHES.	
1. Banded, sandy shales, some layers carbonaceous..	15	0
2. Nodular, yellowish sandstone.....(6 to 8 feet.)	8	0
3. Soft, laminated sandstone.....	4	0
4. Greyish, nodular sandstone.....	4	0
5. Sandy shales, in places slightly carbonaceous. Some ironstone nodules (Reptilian bones and teeth and scales of Ganoids about the middle)...	12	0
6. Nodular ironstone	0	6
7. Grey, sandy clay.....	3	0
8. Carbonaceous shale, or impure lignite.....	0	10
9. Grey, sandy shale.....	8	0
10. Blackish carbonaceous layer, or very impure lignite.	1	6
11. Alternating greyish, yellowish and purplish sandy clays, with occasional soft, or nodularly-hardened sandstones to base of section. Bank presenting a general banded appearance, though beds poorly exposed in detail, about.....	90	0
	146	10

SOUTH SASKATCHEWAN.

Confluence
of Bow and
Belly to Cherry
Coulée.

From the confluence of the Bow and Belly to the mouth of Cherry Coulée,—eleven miles,—the South Saskatchewan flows in a narrow valley between high scarped banks. The rocks exposed are those illustrated in the last section, and continue flat or undulating at very low angles. Vegetation is almost absent from many of the slopes, and the sombre tints of the clays and sandstones give the valley a gloomy and forbidding appearance. Some of the beds yield fossils in abundance, embracing *Ostrea glabra*, *Anomia micronema*, *Corbula perundata*, *Velatella baptista*? *Melania inaeulpta*, *Cameloma multiliniata*, *Viviparus*, *Physa Copei* var, &c.*

The river from this point to the mouth of Swift Current Creek was examined, and a track-survey made of it by Mr. McConnell in the autumn of 1882. Only the upper part of this traverse is, however, included in the area of the present report.

Rocks north of
Cherry Coulée.

For seventeen miles below Cherry Coulée, beds resembling those last described, and at about the same horizon, continue to appear in numerous sections. At the end of this reach, the beds include very little

* Mr. T. C. Weston has since made extensive collections here, which have not yet been examined.

hard sandstone, and the brownish, greyish and yellowish beds alternate with carbonaceous clays, which become impure lignite-coal in some instances. At this place the following section was noted :—

	FEET. INCHES.	
Greyish sands.....		
<i>Lignite-coal</i> , shaly.....	3	0
Black shales.....	5	0
<i>Lignite-coal</i> , shaly.....	5	0
Yellowish argillaceous sands.....		

Below this point, for some miles, the river becomes cañon-like. The brownish earthy-looking beds which above have been exposed in the river banks for many miles, now occupy only one hundred to one hundred and twenty-five feet of the lower part of the scarps, the upper half being composed of light coloured greyish beds, between which and the former the carbonaceous zone intervenes. This arrangement is precisely that described on the Bow (p. 91 c.), and the horizon is undoubtedly the same.

At a point twenty-two miles below Cherry Coulée, two seams of lignite-coal are exposed, the largest being about four feet in thickness. Three miles further down the following section was measured :—

	FEET. INCHES.	
Yellowish sandstone.....		
Shales.....	10	0
<i>Lignite-coal</i> (fair quality).....	4	6
Shales.....	1	3
Sandstone.....	1	0
<i>Lignite-coal</i> (fair quality).....	4	0
Shales.....	6	0
	26	9

The higher coal-seam is one hundred and twenty five feet above the water-level. Still higher in the section two more coal-seams occur, one of which is over four feet thick.

Beyond this locality, the South Saskatchewan passes out of the limit of the map accompanying this report. It may be added, however, that the coal-bearing zone above described continues in the river banks, and is that which yields the lignite-coal of the vicinity of Medicine Hat, which, since the date of the examination here referred to, have been opened and is already somewhat extensively worked. A slope has been constructed from the prairie level to the horizon of the seam, and levels run in on the coal. The screens and houses of the mine are situated at the head of the slope, and a branch line has been constructed to connect this point with the Canadian Pacific Railway. The seam worked here varies from four feet six inches to five feet four inches in

Extension of coal seams to Medicine Hat.

thickness. It contains a clay parting, which in some places is as much as three inches thick. Preliminary openings have been made elsewhere along this part of the river, some of which show a seam somewhat thicker than the above. The quantity of fuel here available is practically inexhaustible, and the quality, though inferior to that of Coal Banks, is such as to fit it for all ordinary purposes. (See p. 12 M.)

LOWER PART OF WILLOW CREEK, AND THE TRAIL FROM
MACLEOD TO CALGARY.

Willow Creek
beds.

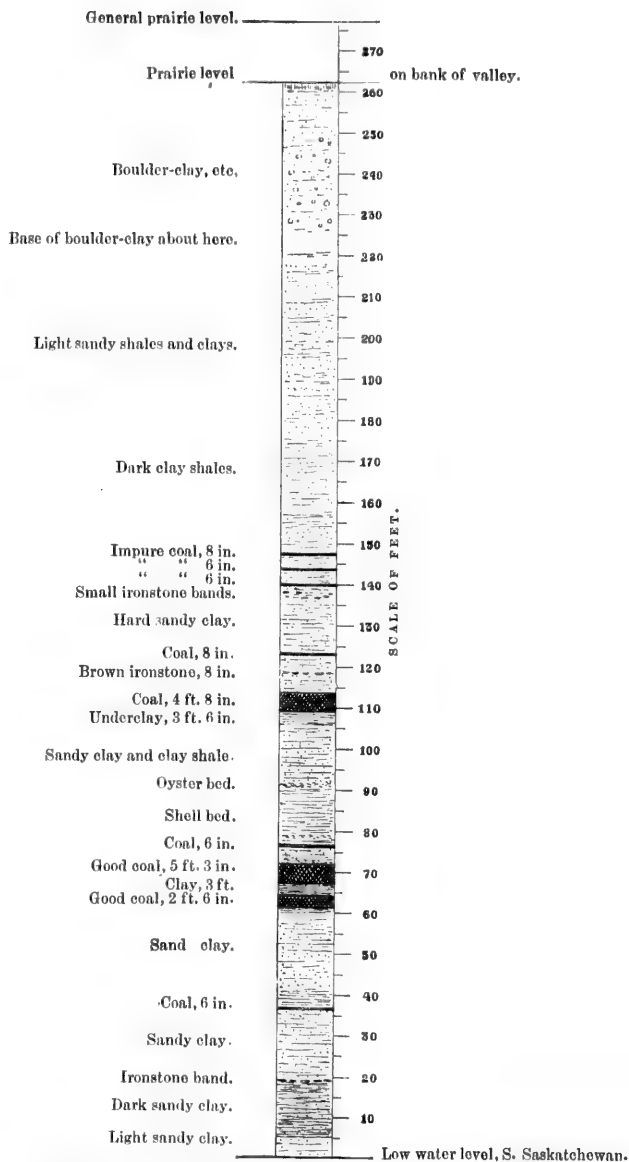
For about thirty-eight miles north-west of Fort MacLeod, the trail to Calgary follows the eastern base of the Porcupine Hills nearly parallel to the course of Willow Creek, the tributaries of which stream flow in at right angles from the hills to the west. Clays and sandstones of the Willow Creek sub-division, with their usual characters, appear near the mouth of the creek, immediately north of Fort MacLeod. Twelve miles north-west of MacLeod, at the "Cut Bank," scarps about twenty feet high show sandy clays, grey, lead-coloured and blackish, in beds which blend together. A few irregular layers of ferruginous sandstone, a foot to two feet thick, are also included, and fragments of crushed shells were found in one place. The characteristic reddish colour of the series is not here shown, and it is probably not far beyond this point that this dies out entirely, leaving the beds which may be so easily distinguished in the southern part of the region, indistinguishable from those of the remainder of the Laramie, on the Bow.

Sixteen miles further on, at the "Leavings," low exposures of greyish, sandy shales and sandstones occur, but offer nothing worthy of note. Still further north-westward some sandstone beds appear in the scarped banks. All these rocks are horizontal or nearly so.

It will be observed that the sections generally on Willow Creek are inconsiderable, and not so instructive as to the composition of the series of the same name, as those of Belly Butte and elsewhere. The beds so-called were, however, first recognized at the mouth of Willow Creek and on the neighbouring part of the Old Man River, and Willow Creek for a considerable part of its course follows their strike.

Northern part
of MacLeod-
Calgary trail.

The northern part of the trail from MacLeod to Calgary, does not fall strictly into the order adopted in this report, for notice here. No sections of any importance, however, occur in its vicinity, or in the banks of the several rivers in the neighbourhood of the crossing places. A few localities show sandstones, which are invariably horizontal or so nearly so that no inclination can be detected in small exposures. These belong to the Laramie. Shaly beds also, no doubt, occur, but are concealed by the sod.



SECTION INCLUDING LIGNITE-COALS NEAR MEDICINE HAT ON THE SOUTH SASKATCHEWAN RIVER (P. 77 C), BY J. P. LAWSON, Esq.

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SCABBY BUTTE.

The prairie region between Willow Creek and the Little Bow River presents, in so far as known, but a single point at which the underlying rocks are well exposed. This is almost exactly on the 113th meridian, five and a half miles south of the 50th parallel, and is known as Scabby Butte. The edge of a low plateau has here been worn away, and shows, according to Mr. McConnell, the following section:—

	FEET.	INCHES.	Section at Scabby Butte.
1. Light yellowish sands	7	0	
2. Brownish, lignitic shales.....	3	0	
3. Greyish and yellowish sands	5	0	
4. Brownish shales	8	0	
5. Light greyish sands, lined in places with yellowish, and holding some thin ironstone layers.	20	0	
6. Lignite-coal	1	3	
7. Lignitic shales	2	0	
8. Greyish sands	6	0	
	52	3	

The chief importance of this section lies in the fact that many ^{vertebrate} bones, apparently of dinosaurian reptiles, are found strewn on its weathered surface. Fossil shells also occur, and indicate the horizon to be the same with that shown at Rye-grass flat, on the Old Man, (already several times referred to), and to represent the transition beds between the Pierre or Fox Hill and Laramie. A *Corbula*, specifically the same with that of Rye-grass flat, is the most abundant mollusc. Mr. McConnell observed no scarped banks or outcrops in the parts of the Black Spring Ridge which he visited; though its occurrence is doubtless in connection with the superposition of the harder beds of the Laramie on the Pierre.

Mr. McConnell furnishes the following notes on Little Bow River, which he examined:—

"Little Bow River heads in some springs near the crossing of Highwood River by the MacLeod and Calgary trail, and running in a south-easterly direction, empties into the Belly about twenty miles below Coal Banks. The valley of the Little Bow above the Blackfoot Crossing trail is wide and shallow, and exposures of rock are very infrequent. Below the trail, good sections occur opposite the Black Spring Ridge. Little Bow River cuts through the Pierre shales and partly through the Belly River and St. Mary River series. Exposures of the Pierre shales commence about three miles below the mouth of Snake Valley, and continue down the river for several miles.

Rocks on Little
Bow River.

Horizon of Coal
Banks seam.

The rocks are of the usual character, consisting of blackish shales below and brownish and chocolate-coloured sandy shales above, and include occasional interstratified beds of greyish sands. Near the base of the formation a small coal-seam about six inches thick was seen, the main Coal Banks seam being concealed. Good sections of the rocks below the Pierre occur about ten miles above the confluence of the Little Bow and the Belly Rivers, consisting mainly of greyish and yellowish sands, sandy clays and sandstone, interstratified with thin beds of ironstone. Near the mouth of the Little Bow the rocks become concealed."

"The rocks of the St. Mary River series are well exposed at all the larger bends of the river between the Blackfoot Crossing trail and the mouth of Snake Valley."

Continuation of
Blackfoot
Crossing seam.

"Near the mouth of Snake Valley a very conspicuous band of argillaceous sands, bleached almost pure white, appears in this formation. These sands alternate with and pass into, in a short distance along their strike, beds stained different shades of yellow and brown. In addition to the sands the section contains thick beds of carbonaceous shales, and beds of greyish, bluish and yellowish sandstones. A small coal-seam, about fifteen inches thick, occurs a short distance above the mouth of Snake Valley. This seam is probably a continuation of that at the Blackfoot Crossing. Above the Blackfoot Crossing trail only a few small exposures were seen. These consist principally of greyish and yellowish sandstones and dark clays. A few very small exposures of Laramie beds occur in the Snake Valley."

SECTION ON BOW RIVER EASTWARD FROM THE EDGE OF THE DISTURBED BELT.

Beds near Coal
Creek.

The belt of flexed and disturbed Cretaceous and Laramie rocks on the Bow River extends from the mountains eastward to Coal Creek, a distance of twenty-five miles. On the west side of Coal Creek several abrupt anticlinals and synclinals of Laramie rocks are found within the length of a mile, and the course of the creek for some distance at least from its mouth coincides with the last of these, and the point at which the beds assume a general eastward inclination. The horizon of the beds is supposed to be near the base of the Laramie. In the scarpel bank on the east side of the creek, near its mouth, associated with sandstones and sandy shales, a seam of good coal, rather variable in character, occurs. It is here, from eight inches to a foot in thickness, and may be traced round the angle of the bank to that bordering the Bow River, and in the opposite direction, for about quarter of a mile from the mouth of the creek, when the dip carries it to the water level of

Coal seam.

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the stream. It might doubtless be uncovered without much labour on the south side of the Bow, in the strike of the beds. Since my visit it has been opened at another locality, a short distance farther up the creek to the westward, and here exhibits, according to Mr. McConnell, a thickness of about three feet of good coal, with several feet of coaly shales. It is much less at a short distance on the strike in each direction, but though evidently very variable, may, in some parts of its extent, constitute a valuable source of fuel. The beds at the mouth of the creek dip N. 47° , E. $< 30^{\circ}$.

By reference to Mr. Hoffmann's analyses (p. 32 M.) it will be seen that this is a fuel of very fair quality, containing 4.93 per cent. of hygroscopic water, but a large proportion of ash. The horizon of the seam probably crosses Jumping Pound River, three or four miles south of the Bow, and this locality is therefore one worth examination.* This coal may occupy the same position in the Laramie as that of the Indian Farm near Pincher Creek, and that elsewhere found near the base of this formation. For about three and a half miles down the Bow, or to the mouth of the Jumping Pound River, similar sandstones, shales and sandy clays appear in a number of places, the sandstones being somewhat more massive and roughly bedded than those before seen, and the whole overlying the coal bed with light eastward dips, averaging a little more than ten degrees. The minimum thickness of beds thus displayed on this part of this river may be stated as about 3,300 feet. Rocks near mouth of Jumping Pound River.

East of the Jumping Pound, within a distance of less than three miles, the river makes a wide bend to the south, and an abrupt northward flexure. The prevalent dips are here westward, implying the existence of a synclinal about the mouth of the Jumping Pound, but the angles observed were very low (5° to 10°), and are probably not constant, and do not result in bringing more than a small part of the rock series above described again to the surface.

It will be observed that the thickness above given considerably exceeds that determined for the St. Mary River sub-division (p. 66 c), in the southern part of the district, and might be expected to bring the Willow Creek beds to view. As elsewhere explained, however, the subdivision of the Laramie applicable in the southern part of the district cannot be carried out in the Bow River region. It is probable, however, that the rocks exposed in a bank about two miles below the Jumping Pound, may represent those of Willow Creek, though wanting the characteristic reddish tint. These consist of sandstones and shales, with some ironstone bands, and are much softer in Comparative thickness of Laramie.

* Since writing the above, I have been informed that the seam has been found here, but apparently in inconsiderable thickness.

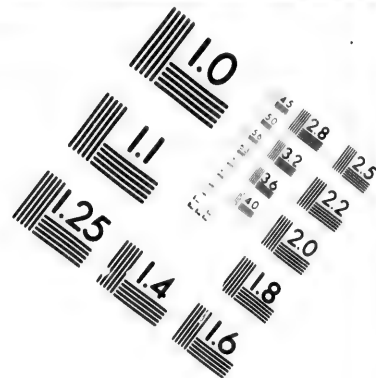
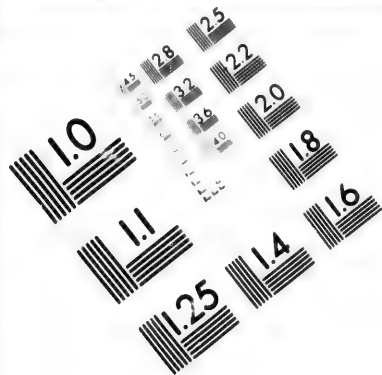
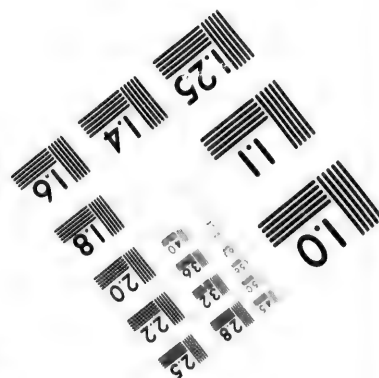
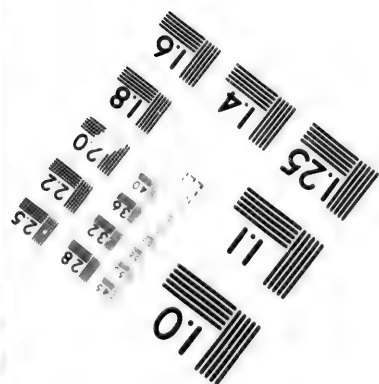
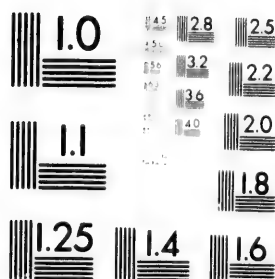


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general character than those above described. They have general brownish and olive colours, and hold, *Goniobasis tenuicarinata*, *Limnæa tenuicostata*, *Unio Aldrichi* or *senectus*, and *Viviparus*. These beds, though not identified, must recur above the Jumping Pound, and might probably reduce the thickness of the representatives of the underlying St. Mary River series to nearly that before given.

Porcupine Hill
series west of
Calgary.

From the point to which the description has been carried above, to Calgary—twenty miles—the rocks are seen in the scarped banks of the river in a number of places, and are generally horizontal, or very nearly so. They consist, for the most part, of sandstones, which are often quite massive, and generally differ from those of the lower part of the formation in colour, being yellowish-grey instead of greenish-grey. One cliff on the south side of the river exhibits about one hundred feet in thickness of soft sandstone, and the edge of the plateau, in the immediate vicinity of the river, rises from 250 to about 500 feet above it, indicating a considerable additional thickness of Laramie rocks. Olive-green and blackish-grey shaly beds, often almost clays, also, however, occur in some places, and occasionally hold crushed shells resembling those last referred to. A small cliff, composed of sandstone of the character above noted, appears on the east side of the Elbow River at Calgary. The rocks on this part of the Bow, with little doubt, represent those of the Porcupine Hills subdivision of the Laramie, and closely resemble them in lithological character.

Boulder-clay.

At several places between the Jumping Pound and Calgary, sections of boulder-clay occur. In one bank, six miles above Calgary on the north side of the river, blocks of sandstone from the Cretaceous or Laramie, in some cases eight feet in diameter, were observed to be strongly glaciated. These are associated with boulders from the Rocky Mountains, and the whole imbedded in a rudely stratified sandy clay. No Laurentian fragments occur, nor were any observed in the gravels of the river west of Calgary, though a few were found at that place.

Calgary to
mouth of
Hi. wood.

From Calgary to the mouth of the Highwood River,—a distance of twenty-four miles by the course of the stream,—the rocks maintain so great a general similarity in character that it is unnecessary to note in any detail the composition of the numerous exposures examined. The beds are, as a rule, nearly horizontal, but the dips, so far as observed, are westerly or north-westerly at very low angles, and this, with the eastward slope of the river bed, appears to render the section in the main a descending one. The rocks are still for the most part sandstones of general yellowish and grey tints, and seldom much indurated. Shaly beds of olive, brownish and grey colours also, how-

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ever, occur, and appear to be most abundant on that part of the river which runs southward between Calgary and Fish Creek. They were also observed in a bank about three miles above the mouth of the Highwood. The beds on this southward-flowing reach of the river, it is presumed, represent those above referred to as probably the equivalents of the Willow Creek series. Traces of carbonaceous matter and obscure fragments of plants also occur, but none of a determinable character were found. Boulder-clay is frequently exposed and sometimes in considerable thickness. Laurentian fragments were again found on the river at about four miles above the Highwood, but none are of large size. The boulder-clay was here also observed, for the first time in the section on this river, to rest on a shingly deposit of quartzite gravel, like that elsewhere described as intervening between it and the underlying rocks.

In a bank about one-fourth of a mile up the Highwood, on the east side, associated with sandstones, sandy shales and shales like those above described, at a height of thirty feet above the water, a seam of lignite-coal three inches in thickness occurs. It appears also in the north bank of the Bow immediately below Highwood River, about fifty feet up in the bank, and at about a mile further down the river, is again seen in a scarped bank one hundred feet high, at a height of seventy feet above the water. It is, wherever observed, quite too thin to be of economic importance. The beds at the last mentioned locality have a light dip westward, at an angle of about 5° , and a few feet below the horizon of the seam there is evidence of contemporaneous local erosion, hollows having been produced which cut across the edges of some of the beds. In these a coaly layer occurs which has, locally, a thickness greater than that of the overlying seam. This seam is possibly represented by that which occurs at the junction of Sheep Creek with the Highwood. The seam is there about nine inches thick, and the quality poor. The beds appear to be horizontal.

For six miles below the Highwood, the Bow is hemmed in closely by banks one hundred and fifty feet high, which are scarped on alternating sides of the river, and present an almost continuous exposure of beds which show locally light undulating dips, but probably on the whole maintain a very gentle inclination westward. The rocks are sandstones of general dull greenish-grey colours, sometimes rather massive, but more often well bedded, and alternating with greenish-grey or brownish, and occasionally somewhat rusty, shaly clays; the whole, from a distance, when prominent sandstones are absent, often presenting a brown colour and earthy appearance. Some very obscure vegetable impressions were seen, and in an exposure immediately below the cañon, specimens of *Unio* and *Viviparus* were obtained. These

Equivalency of beds may be supposed, in a general way, to represent those which occur immediately to the east of the Willow Creek series on the Old Man River, and those which form Gooseberry Cañon on the St. Mary.

From this point, for about twenty-six miles, the rocks shown in occasional sections in the banks possess no special interest. They are chiefly sandstones which are often somewhat massive, but are occasionally associated with shales. They are horizontal, or very nearly so, and the section is not sufficiently continuous or provided with sufficiently well marked zones to enable one to determine whether the beds have any general direction of inclination. Boulder-clay, generally brownish and earthy, is seen in a number of places, and invariably caps the sections in greater or less thickness.

Sections near Arrow-wood.

At the point now reached, however, near the south-western angle of a wide southerly flexure of the river, a low bank shows about twenty feet of sandstone and shaly clays, among which a coal-seam one inch in thickness is included. Obscure impressions of plants also occur, and in a grey soft sandstone at the water's edge *Unio Aldrichi* or *senectus*, *Goniobasis tenuicarinata*, *Viviparus*, *Cassopella* and *Sphaerium*, with fragments of reptilian bones. Above the whole lies fifteen to twenty feet of the shingly drift, and over this ten feet or more of hard boulder-clay.

Mingling of brackish and fresh-water forms.

About two miles further down the river, on the east side of the mouth of the eastern Arrow-wood Creek, a very interesting section occurs, in which beds of marine or brackish origin are found immediately underlying, and passing up without the least unconformity or break of any kind into those which are shown by their fossils to be fresh-water. The section in the bank is as follows, in descending order. The beds appear horizontal, but their relation to those last described above, shows that there must be a general light westward dip. The measurements given are approximate only:—

	FEET.
1. Soil and subsoil.....	6
2. Gravel.....	6
3. Soft sandstones with two zones of large ironstone concretions	16
4. Harder sandstones	15
5. Small hard ironstone balls, irregularly scattered.....	..
6. Soft laminated sandstones.....	8
7. Carbonaceous clay, with thin streak of coal.....	4
8. Soft sandstones, shaly beds	15
9. Thin irregular ironstone layer.....	..
10. Somewhat harder sandstones, with <i>Unio</i> , <i>Viviparus</i> , etc.....	20
11. Ironstone and ferruginous sandstone filled with <i>Unio Danæ</i> , <i>Viviparus</i> , etc.....	3
12. Soft sandstone, with some sandy shales.....	10
13. Somewhat harder sandstone, charged with <i>Corbicula occidentalis</i> , <i>Unio Danæ</i> and <i>Ostrea</i>	30

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The general colour of the rocks here shown is yellowish-grey, but when unaffected by the weather they have no yellow tint.

Two miles below Arrow-wood Creek, on the south side of the river, rocks similar in appearance to the last, and horizontal or nearly so, appear. In a layer of ironstone a foot thick, at the water's edge, abundance of marine or brackish-water and fresh-water shells were found, including *Corbula*, n. sp., like *C. pyriformis*, *Corbicula* like *C. Durkei*, *Physa Copei* var., *Unio*, *Viviparus* and *Goniobasis*. For about five miles further similar beds, still horizontal, continue and are seen in a number of places, till at the point at which the river again turns northward (four miles south-east of Blackfoot Crossing) a section, still nearly in the same horizon, shows seams of lignite-coal. A narrow tongue of land from the north here forms a peninsula, and the best exposure is in the lower end of the scarped bank on its west side. The beds here present the following arrangement, in descending order:—

	FEET.	INCHES.
1. Soft, greyish sandstones.....	10	0
2. Lignite-coal (8 in. to 1 ft.).....	1	0
3. Dark grey clay.....	0	8
4. Pale grey, sandy clay, with roots.....	1	0
5. Dark grey, somewhat carbonaceous clay.....	2	6
6. Grey banded sandstone, ironstone balls.....	3	0
7. Lignite-coal.....	0	3
8. Irregular layer of sandstone (0 to 4 inches).....	0	4
9. Carbonaceous sandstone, with thin coaly layers.....	1	9
10. Grey soft sandstone, with some shaly layers, and ironstone balls (partly concealed).....	10	0
11. Lignite-coal (irregular) at water level.....	0	6
	31	0

Sections near
Blackfoot
Crossing.

The ironstones hold in some places a great profusion of well preserved and large shells of *Viviparus Leai*? with *Unio Danae*. The lignite-coals are not here sufficiently thick to possess economic value, but are of interest, as they with little doubt represent those which immediately below the Blackfoot Crossing assume considerable dimensions.

From this point, the river turns abruptly northward, and then making an eastward bend, in six miles reaches the Blackfoot Crossing. No sections of the underlying rocks were observed in this part of the river, but in two places the banks showed shingly quartzite drift overlain by boulder-clay, and the whole covered by a thick coating of sand similar to that which forms a series of sand hills at a short distance from the valley.

Immediately below the Blackfoot Crossing the banks show small sections of sandstones and shales, with traces of lignite-coal, but

Sections below
Blackfoot
Crossing.

Lignite-coal.

disturbed by slides. Four and a half miles below the Crossing, however, on the north side of the river, an excellent section which presents the lignite-coal seams of this locality in their best known development, occurs. The coal is here favourably situated for working, the lowest seam being about thirty feet above the water's edge and nearly horizontal. The underlying rock is a somewhat hard whitish sandstone. The section is as follows:—

	FEET. INCHES.	
Coal	1	8
Black carbonaceous shale	1	4
Coal	1	8
Shale	0	3
Coal	0	9
Shale	0	3
Coal	2	0
Shale	1	0
Coal	1	10
Total.....	11	10
Total coal	8	11

Nearly opposite, on the south side of the river, the coal with a similar development, appears at intervals in the scarped bank for at least a quarter of a mile. Though practically horizontal in the main, it is affected by a number of light undulations. Below this scarped bank a wide, flat-bottomed valley, which has evidently been at a former period occupied by the river, opens, and after making a circuit to the south rejoins the river some miles lower down. In the eastern arm of the old valley a small brook flows, which at about a mile back from the river enters the old river-course by a narrow, steep-sided coulée. In the latter, numerous exposures of the same coal-bearing horizon are found. In the south side of the wide old valley, for some distance east of the point at which the brook joins it, the position of the coal is also marked by shales reddened by its combustion along the outcrop.

Outcrops of coal south of river.

The coal is last seen to the south, two miles up the brook valley from the river, at a point six and a half miles south-east of the Blackfoot Crossing. At this place a small quantity of coal was extracted for use at the Blackfoot Agency. The deposit here consists of two seams, separated by about a foot of carbonaceous shale, the upper averaging 1 foot 8 inches in thickness, the lower 3 feet. The bed may be traced here for about 500 feet in the natural exposures, and is affected by variable dips which do not exceed 5° in amount. The seams pass below the level of the bottom of the coulée at the upper end of the exposures. Their thickness is nearly uniform, and they would afford, say, 4 feet 6 inches

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of clear coal, the whole of which might be worked at once. The immediate banks of the coulée at this place are about eighty feet high, the upper two-thirds being composed of drift deposits which rest on a worn undulating surface of the rocks below. The general surface of the prairie is over one hundred feet above the level of the coal.

In following the coulée northward from the spot just described, the coal is frequently seen in the right, or east bank, for about a mile, or to the wide old valley previously mentioned. Owing to the slope of the bottom of the coulée towards the river, the beds are cut into more deeply near its mouth, and at the last exposure the coal is about thirty feet up in the bank. The upper seam is here not well exposed, but the lower exhibits a few inches over four feet of good coal. In an exposure intermediate between this and the first, the upper seam is 8 inches thick, the shales 1 foot, and the lower seams 4 feet 4 inches. The seams are underlain by at least twenty feet of soft whitish sandstone.

The natural exposures thus serve to prove the continuity, in good workable thickness, of this coal deposit over a tract of country at least several square miles in extent. Its moderate depth below the surface of the plains, and nearly horizontal attitude, would enable it to be proved by boring, at a small expense over any desired area, and before undertaking any mining operations away from the visible outcrops, it would be advisable to test it in this way, owing to the knowledge of its variability already obtained.

Proved coal-bearing area.

On Crowfoot Creek, about six miles north-east of the Blackfoot Crossing, Mr. McConnell observed a seam of coal about eighteen inches in thickness, which he describes in a succeeding page. This at the time was supposed to represent one of the closely associated groups above described on the Bow River. Since the railway has traversed this part of the country, however, several borings have been carried out in the vicinity of the line in townships 21 and 22, ranges xx. and xxi., by Mr. Ducker, working under the direction of the Canadian Pacific Railway Company. Mr. J. H. McTavish has kindly furnished me with details of these borings, which show that the seam observed in the natural exposures on Crowfoot Creek is more than sixty feet above the horizon of the main seam shown on the river, and that the main seam retains much the same thickness as on the river exposures, but is at a lower level, in consequence of the persistence of the light north-westerly dip which here affects the beds. It will therefore be very easy to open this seam by a shaft sunk to a moderate depth beside the railway line.

Borings made by C. P. Ry. Co.

Of Mr. Hoffmann's analyses (pp. 19-21 m.) Nos. 12, 13 and 14 refer to specimens collected from different outcrops of the seam above described. No. 15 is from the seam on Crowfoot Creek, mentioned in

the preceding paragraph. This fuel contains considerably less hygroscopic water than that of the Medicine Hat mine, though less like a true coal in physical character.

Great depth of
boulder-clay.

Immediately below the mouth of the small stream on which the above described exposures of the coal are found, a bank showing an imperfect section, which may have been disturbed by a slide, occurs. Below this point, for a length of about seven miles in a straight direction, the river's course continues extremely tortuous, and though high scarped banks characterize almost every bend, they are composed exclusively of boulder-clay, which forms the whole height of the bank, often one hundred feet. If the underlying shingly deposit occurs, it is below the present river-level, and we evidently have here a wide pre-glacial hollow, which has been filled by the drift deposits.

Horse-shoe
bend.

The underlying rocks again appear four miles below the mouth of Crowfoot Creek, on the south bank, and are still referable to the Laramie series. Small broken hills, remnants of the elevated edge of the plateau, fringe the river. They are composed of sands and sandy clay, in places reddened by the combustion of lignite-coal seams. From this point, the river flows three miles due east, and then turning abruptly back on its former course, produces a sharp flexure, which, for want of a better name, I have called Horse-shoe bend. The bank at the outer side of this bend is again composed of boulder-clay, but to the south of it, fine exposures occur on the right bank of the river of the rocks already imperfectly seen in the hills above alluded to. The river-bank here assumes the broken hummocky character with bare hills and deep intervening ravines which is generally designated bad-lands in the west. The banks rise irregularly from the river to a height of about two hundred feet, and are composed at the base of brownish and fawn-coloured sandy clays, and grey or yellowish-grey sands, or very soft sandstones, with thin ironstone layers. Towards the top, whitish and pale-grey soft sandstones predominate, and there again show marks of the combustion of lignite-coal.

Coal seams
near Horse-
shoe bend.

A short distance further on, three miles nearly due south of Horse-shoe Bend, a high scarped bank affording a fine section occurs on the same side of the river. The beds in this region must have a pronounced general westerly dip, and those above described be near the base of the Laramie, for, capping the cliff at this place, at a height of one hundred and thirty-five feet above the river, is a bed of lignite-coal, and below it to the water's edge are the Pierre shales. This coal seam must underlie the whole of the rocks seen in the bad-land exposures, and is not the same with that the combustion of which has produced the reddening above alluded to. The latter must occupy a place in the series about two hundred feet higher, and was not any

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where found well exposed, so that its thickness or character might be determined. The discontinuity of the exposures and variability of the dip, further renders it uncertain whether the upper seam is the same with that occurring about the Blackfoot Crossing, or yet another intermediate between it and the base of the Laramie. The question can probably only be solved by a boring carried at least two hundred feet below the Blackfoot Crossing seam in the region where it is well defined.

The coal-seams capping the cliff above described, may either be regarded as forming the base of the Laramie, or summit of the Pierre. The Fox Hill sandstones, elsewhere well defined, are here either wanting or inseparably blended with the Laramie. The coal seam appears again on the opposite bank, a short distance down the river, making a total length of outcrop here seen of half a mile or more. It is four feet four inches in thickness, compact and hard when not long weathered, and differs considerably in physical character from that of the Blackfoot Crossing, being divided by vertical cleat planes in such a way as to break into cuboidal blocks, which resist the action of the weather better than the irregular fragments derived from the conchoidal-fracturing or shaly fuels. This seam was, however, not recognized either on the Red Deer River to the north, or in the southern part of the district, and is therefore local in character.

This seam is represented by No. 16 of Mr. Hoffmann's analyses (p. 22 m.) It contains 11.13 of hygroscopic water and 9.19 of ash.

The beds here underlying the coal to the water's edge do not present the ordinary blackish color of the Pierre shales, but represent the upper portion previously described on the Old Man River (p. 69 c). They are rather soft sandy clays or shales of general rich brown tints and banded aspect, with occasional grey, red-weathering ferruginous and calcareous layers, which are usually hard.

From this point, the Pierre shales characterize the banks for a distance of about thirty miles by the course of the river, or twenty miles at right angles to the strike. The general westward dip no doubt continues, but it is so light that it can scarcely be observed. For some miles below the cliff-section above described, brownish colours are characteristic of the rocks, and the thickness of this part of the Pierre must here be considerably over one hundred feet. The drift deposits are almost absent in the section above described, for several miles, and further down seldom exceed fifty feet in thickness. As lower beds are gradually reached, the ordinary slaty-grey or blackish colour of the Pierre appears. Fossils are moderately abundant in a few places, and layers of ironstone concretions also occur. At about twelve miles down the river a zone of very soft sandstone of a pale

Coal at summit
of Pierre shales.

Wide belt of
Pierre shales.

Sandy intercalation in Pierre.

grey tint, and including some ironstone layers, appears at the water's edge. A few fragments of marine fossils were found in this, but very badly preserved. This intercalation in the Pierre must have a thickness of about fifty feet, and though the exposures are not extensive in this part of the valley, it may be seen gradually rising in the bank for several miles, till it eventually passes above the top of the section. The beds underlying it have the usual character and colour of the Pierre shales, and in a cliff a mile above Grassy Island have a thickness of at least one hundred feet. The sandy intercalation in the Pierre is again found even more largely developed on the Red Deer River to the north. The portion of the river-valley occupied by the Pierre rocks is sombre and forbidding in appearance. The banks, though not so high and steep as in some other places, are frequently almost destitute of vegetation, and very extensive land-slips have occurred in many places, giving them a ruined and desolate aspect.

Grassy Island coal seam.

At Grassy Island, the base of the Pierre, with the coal-bearing horizon elsewhere characterizing it, is found; the first outcrop of the coal and harder beds associated with it, at the water level, producing a little rapid about a mile and a half above Grassy Island. The best exposures occur in the scarped banks on the south side, near the island, the north bank being quite low near the river, and rising gradually in grassy slopes. In their general arrangement, appearance and thickness, the seams here exposed correspond closely with those about Coal Banks on the Belly River, fifty-seven miles distant, and show the remarkably constant character of this coal-bearing zone. The beds at Grassy Island have a general westward or north-westward dip at an angle of about 5°. The section including the coal-seams, as constructed from several exposures in this vicinity, is as follows:—

	FEET.	INCHES.
Lead-grey shale.....	25	0
Coal	1	6
Soft, grey and yellowish-grey shaly sandstone.....	13	0
Carbonaceous shale, coaly streaks.....	2	3
Coal (good and sound throughout).....	4	6
Dark grey shale and shaly clay.....	7	0
Coal	1	0
Carbonaceous shale.....	1	0
Coal	0	6
Soft shale and clay.....	8	0
Coal and carbonaceous shale (to water)	1	6

The seam of 4 feet 6 inches in thickness may be assumed to be the representative of the "main seam" at Coal Banks. It is superior in quality to that of the Blackfoot Crossing, differing from it in physical

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character in the manner above described in connection with the Horse-shoe bend seam, but it is inferior in composition to that at Coal Banks. (See analysis No. 11, p. 18 m.)

Below Grassy Island the inclination of the beds must become very light, for at a distance of about two miles to the east, in a low exposure on the north bank of the river, at the water's edge, one of the coal seams was again imperfectly seen. Thence for a distance of ten miles,—the river flowing almost due south,—occasional low exposures near the river show from ten to thirty feet of pale greyish and greenish-grey sandstones, generally soft, covered above by boulder-clay to the top of the scarped banks which are here less than sixty feet in height. These beds show occasional coaly streaks, and in one place *Unio* and fragments of bone were observed. For the next ten miles the river still flows southward, but with more easting, the banks seldom exceed fifty feet and boulder-clay only was seen in the few scarps which occur.

Two and a half miles west of the 112th meridian, the river makes a right angle, turning abruptly to the east. Here greyish and ferruginous sandstones occur, somewhat irregularly hardened and bedded, and including some ironstone, but in low poor exposures. Similar small exposures appear here and there for about five miles further, but show no marked peculiarities. At two and a half miles east of the 112th meridian, the country on both sides of the river rises suddenly to a considerably greater elevation, probably over one hundred and fifty feet above the water-level, and in a broken scarped bank one hundred feet in height, fifty feet of similar rocks, to all appearance quite horizontal, and overlain by boulder-clay, are exposed. Smaller exposures of beds of the same series are found for nine miles beyond. The bedding is usually rude and massive, with harder sandstones, which are usually ferruginous, forming projecting layers. Large ironstone concretions, often several tons in weight, are included in the sandstones in numbers so considerable that they may eventually prove of economic value. They are often, however, solid ironstone in the centre only, and pass gradually outward into ordinary ferruginous sandstone with a comparatively small percentage of iron.

At the point last defined, nine miles east of the 112th meridian, an impure lignite-coal or carbonaceous shale was for the first time seen in this series on the Bow, at a height of twenty feet above the water. In several places within the next few miles carbonaceous zones recur, varying from three to five in number, and occasionally becoming lignite-coal, but too impure and thin to possess any importance. The beds undulate slightly, and in one bank were noticed to have a distinct north-eastward dip at a very low angle. Twelve and a half miles east

Rocks of Belly River series.

Exposures near 112th meridian.

Large ironstone concretions.

Thin coal seams.

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of the meridian the river becomes fringed on the south side, for a short distance, by broken bad-lands which exhibit fine sections. The coaly zone is here seen in places nearly fifty feet above the river, overlain by about a hundred feet of the pale grey sandstones which contain ironstone concretions in great abundance. These have been described as occurring at the water-level further up the river. For four miles eastward the undulations of the beds become more marked than before, and the general north-westward inclination must here be locally reversed, for the coal-bearing zone descends to and in places passes below the water-level. At the point now reached,—fourteen miles north of the mouth of the Bow,—this zone includes, at the edge of the water, a seam of fair lignite-coal eighteen inches in thickness. The coal is separated into two parts by a shaly layer of three inches, not included in the measurement. This seam is without doubt the continuation of that described on page 75 c.

Sections near
mouth of Bow.

Two miles below, the river again turns definitely to the south, but shows nothing but boulder-clay in its banks for about nine miles, or to within six miles of its mouth. A low bank of dark shaly beds with flaggy sandstones and ironstone here occurs, holding numerous specimens of *Corbula perundata*, *Ostrea*, etc. One more similar exposure was noted between this place and the mouth of the river, where beds of the same series, previously described, are again found displayed on a much grander scale.

ROCKS BETWEEN BOW AND RED DEER RIVERS, AND ON THE RED DEER RIVER.

The following notes on the country north of the Bow and the Red Deer Rivers, with the ensuing section on the Porcupine Hills, are by Mr. McConnell, who conducted the examination of these portions of the field.

Crowfoot Creek

"Between the Blackfoot Crossing and the mouth of the Rosebud or Arrow-wood River, exposures of rock along the route passed over are very infrequent. In Crowfoot Creek, about six miles from the Blackfoot Crossing, and near the place at which the Lord Lorne trail enters its valley, a small coal-seam about eighteen inches thick was seen. The same seam, but with somewhat increased thickness, is exposed again about a mile farther down the stream, and is then seen to be associated above with rather hard, grey sandstone, and beneath with a small bed of clay. After leaving Crowfoot Creek, no further indications as to the character of the rocks lying beneath the surface were met with, until the Wintering Hills were reached.

Wintering
Hills.

"The Wintering Hills form a wide, rough ridge, running in a south-easterly direction from Rosebud River and presenting a steep

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escarpment plain slopes of the dip of the trail is about Crossing, and the mouth of "Both fluvial sandstone. coarse in texture existence of softer and more siliceous plastic clays, and greatly succeeded by and streaked fossils were found.

"The sequence described by the Deer River in river, the prior north-east the plunging from the dip of the doubt that at axis of which Red Deer River highest part of

"The Red River usually sand all the way down average rate of "Near the valley are coming with some sandstone. The pulses running gradually detailed to the degree which they have trace, and all

escarpment to the north-east, from the base of which a rough, hilly plain slopes gently down to the valley of the Red Deer River. The slope of the ridge to the south-west is very gradual, and may not exceed the dip of the strata. The summit of this ridge where crossed by our trail is about 460 feet above the level of Bow River at the Blackfoot Crossing, and about 800 feet above the level of the Red Deer River at the mouth of the Rosebud.

Both flanks of the ridge near its summit afford good exposures of sandstone. These sandstones are greyish and yellowish in colour, rather coarse in texture, and very hard, and to their protecting influence the existence of the hills is undoubtedly due. They are underlain by a softer and more friable variety of the same rock, alternating with more argillaceous beds, and these are followed by about sixty feet of dark plastic clays, which are well exposed near the base of the escarpment, and greatly resemble in appearance the Pierre shales. The clays are succeeded by light-coloured argillaceous sands, very slightly indurated and streaked at intervals with thin, reddish, clay-ironstone beds. No fossils were found in any of these rocks, although they were carefully searched.

The sequence of the beds in these hills is almost identical with that described by Dr. Hector, as occurring on the other side of the Red Deer River in the Hand Hills, in which, reversing the order south of the river, the principal escarpment faces to the south-west, while to the north-east the hills slope gently away with the dip of the strata, and judging from the relative position of these two series of hills, and from the dip of the rocks which compose them, there seems little reason to doubt that at one time they formed part of a wide low anticlinal, the axis of which is now occupied by the deep, gorge-like valley of the Red Deer River. The river is now about 1,300 feet beneath the highest part of the fragments of the anticlinal yet remaining.

The Red Deer River varies in width from 150 to 300 yards; its bed is usually sandy, and sand-bars and sandy islands occur at intervals, all the way down. The current, at the beginning of July, ran at an average rate of about $1\frac{3}{4}$ miles per hour.

Near the mouth of Rosebud River, the rocks forming the river-valley are composed principally of pure and arenaceous clays, alternating with some beds of indurated sands, and with a few seams of clay-ironstone. These rocks, being very soft, are greatly cut up by deep gullées running back from the river, the ramifications of which, uniting, gradually detach small portions of the plateau, and leave these an easy prey to the degrading influence of sub-aërial erosion, by the agency of which they have been sculptured into dome and pyramid, scarp and terrace, and all the endless variety of form characteristic of the "bad-lands."

Rocks in Wintering Hills.

Anticlinal of Wintering and Hand Hills.

Red Deer River

Rocks near mouth of Rosebud.

Bad-lands.

lands" of the West. The effect in this instance is intensified by the brightness and rapid alternation of the colouring, thin beds of red, yellow, brown, grey and white, extending along the banks with ribbon-like regularity for miles.

"About half a mile below the mouth of Rosebud River, and near the base of the section, a bed of silicified wood was observed. This bed, which is about one foot thick, is, on a fresh fracture, of a deep brown-black color, but on exposure to the atmosphere weathers to a light cream colour. The same bed is mentioned by Dr. Hector as occurring near the mouth of Shell Creek, about three miles and a half further down the river. The section including it is given by him as follows, in descending order:—*

Section by Dr.
Hector.

	FEET.	INCHES.
Buff, unstratified earthy clays.....	12	0
Ash-grey and cream-coloured sandy clays in bands, with stems of clay-ironstone and carbonaceous layers.....	30	0
Seam of pure lignite.....	3	0
Banded clays, sandy in places.....
Silicified wood, composed of stems, trunks and roots of large trees.....	1	0
Brown coal.....	1	6
Sandy clays, varying from grey to light cream colour.....	100	6

"The coal seam included in the above section can be traced by numerous exposures from the mouth of Rosebud River down the stream for a distance of about eleven miles, at which point it reaches the surface and is cut off at a height above the river of about 275 feet. It is seen again for a short distance about eight miles further down, near the mouth of a large coulée, its re-appearance being due to the greatly increased height of the plateau above the river. The side of the valley south of the river at this point is 550 feet high, and the coal appears in the bank about 440 feet above the river-level.

Coal-seam in
Laramie.

"This seam belongs to the same geological horizon as the coal at the Blackfoot Crossing, and it is quite possible that the two seams may be identical and so underlie the whole country between this part of the Red Deer River and the Bow River.

"On the Red Deer River this seam is seen at its best in a small coulée about four miles below the mouth of the Rosebud River, where it is over six feet thick. Three miles further up the stream it measures four feet, while down the stream it shrinks in some places to two feet, but enlarges again considerably before it finally disappears. The coal is usually associated, both above and below, with a varying quantity of carbonaceous shales, but these are not constant, and die out occasionally when the coal comes in direct contact with the sandy clays beneath. In many places this seam has been entirely burnt away, and the red clays

* Quart. Journ. Geol. Soc., Vol. XVII, p. 425.

seen at intervals along the valley are due to its combustion. The height of the coal-seam above the top of the Pierre is about one hundred and sixty feet.

"The total thickness of the rocks exposed in the sections along this part of the river and in the Wintering Hills, measuring from the top of the Pierre up, is about 990 feet, of which the greater part is composed of pure and arenaceous clays, and differs greatly in lithological character from the Fox Hill proper which occupies the same relative position farther south, and which is distinctively a sandstone formation.

Thickness of rocks.

No Fox Hill sandstones West edge of Pierre shales.

"About two miles below Shell Creek, the Pierre shales appear at the water-level, the slight dip they have to the north-west bringing them to the top of the bank about seven miles further down. The rocks forming the upper part of this formation consist here of sandy clays, containing in places thick beds of greyish sands, the sands never being persistent for any great distance.

"The clays vary from a light yellow to a deep coffee colour, the different shades alternating with one another in layers only two or three inches thick. About 500 feet of these clays is seen. They are underlain by about 250 feet of darker shaly clays, which have a much greater resemblance than the preceding to the typical Pierre shales.

Upper beds of Pierre.

About two miles below Snake Creek, and near the base of the Pierre shales, a small coal-seam about eighteen inches thick was observed. This seam is probably an extension of the seam at Grassy Island on Bow River, and of the Coal Banks seam on Belly River.

"The Pierre shales are seen along the valley of the Red Deer River for about thirty miles, and are well exposed in the scarped faces of many of the rolling hills forming its banks, as well as at all the principal bends of the river. They are underlain by the Belly River series, which first appears near the water-level, about four miles below Snake Creek, but soon rises to the top of the banks, and shows nearly continuous sections for a distance of almost fifty miles.

Width of Pierre belt.

Belly River series.

These rocks consist mainly of greyish argillaceous sands, alternating with greyish sands and greyish and yellowish sandstone. In places also thick beds of greyish and dark clays, and thin beds of ironstone, were seen. About ten miles below Snake Creek, a couple of coal seams appear on the bank, the larger of which is about three feet thick, but the coal is of inferior quality. Around Dead Lodge Cañon a large area of these rocks has been worn into bad-lands.

Coal-seams.

"Opposite the Rainy Hills, the Pierre shales re-appear capping the scarped banks of the valley. Here, near the centre of the shallow synclinal which they form, they have a thickness of about 250 feet. As generally found elsewhere a small coal-seam occurs near their base.

Synclinal of Pierre shales.

"Although no sections of Pierre were seen between Hunting Hill and

Dead Lodge Cañon, it is probably continuous along this part of the river a short distance back from the edge of the valley.

Edge of Pierre
shales.

Rocks on lower
part of Red
Deer.

"The Pierre shales disappear about five miles west of the 111th meridian, and are followed in the course of three or four miles by the Belly River series. In the next ten or twelve miles no rocks of any kind were seen, the sides of the valley being low and covered with grass. The absence of exposures in this distance is probably due to the occurrence of a drift-filled depression in the Cretaceous rocks. Twenty-five miles west of the Forks the plateau again rises, and has forced the river to make a sharp bend to the north-west. Around this bend, and above it for a few miles, exposures occur which probably belong to the lower part of the Belly River series. The rocks seem to be more compact than those last seen, and contain a larger proportion of yellowish sands and sandstone. They also hold a small coal-seam. East of the bend the valley widens out, and its banks become grass covered, and show nothing but drift all the rest of the way down to the Forks or confluence with the South Saskatchewan."

THE PORCUPINE HILLS.

"The geological structure of the Porcupine Hills is very simple. They consist principally of sandstones belonging to the upper part of the Laramie, which has been designated as the Porcupine Hill subdivision. These rocks have been thrown into a gentle synclinal form, the highest dip observed not exceeding ten degrees.

Character of
rocks.

"Numerous small exposures of sandstone are found scattered over the hills, but these represent only the harder varieties of the rock of which they are composed. This sandstone is soft, coarse-grained, and usually of a greyish or light brownish colour, the more massive varieties often showing false-bedding, the laminae being about an inch to an inch and a half thick.

Sections in
Willow Creek.

"More instructive sections are found in the valley of Willow Creek, one branch of which cuts through the hills transversely. These show fine- and coarse-grained sandstone, often weathering to a light yellow, and alternating with bands of more thinly bedded sandstones, clays and shales.

"The only fossils found in these rocks were fragments of *Unio limnaea*, and a few other fresh-water shells.

Thickness.

"The total thickness of the beds forming the Porcupine Hills cannot be less than 2,500 feet."

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PINCHER

As already mentioned, the base of the vertical, Fork of the river west by the bend, and appears upward, and generally probable the rocks actually.

The position which traverses North of the foot-hills to the west by Mr. Meslin, clearly shows sections at this chapter.

Pincher Creek, eastward for a distance of through some southernmost northward from the upper part and the rock is a good section of Pierre-like sandstone immediately west of the low in these. of the Drywater to Mill Creek, the road-crossing is greenish-grey with a northward represent the massive collection them by Meslin, crossing the purplish-grey

PINCHER CREEK, MILL CREEK, SOUTH, MIDDLE AND NORTH FORKS OF
OLD MAN RIVER.

As already stated, the foot-hill belt is characterized geologically by ^{Foot-hill belt.} Cretaceous and Laramie beds, with a strike generally parallel to the base of the mountains, sharply folded, and resting at all angles up to vertical. With the exception of a single gap through which the South Fork of the Old Man issues, it is everywhere sharply bounded to the west by the Palæozoic rocks of the mountains. The line of junction appears usually to be a faulted one, with extensive down-throw eastward, and the Cretaceous or Laramie rocks near the line of contact, generally dip westward, or toward the mountains. It is, however, probable that in some cases, owing to overturned folds, the Palæozoic rocks actually overlie the Mesozoic along the line of junction.

The portions of the St. Mary, Upper Belly and Waterton Rivers which traverse this belt, have been described on a previous page. North of the North Fork of the Old Man, the streams which cross the foot-hills to and including the Elbow River, are noticed in the sequel by Mr. McConnell, and the arrangement of the beds in their banks clearly shown in his sections. A few notes will here be given of the sections afforded by the streams enumerated at the head of this chapter.

Pincher Creek, after leaving the Palæozoic rocks, flows north-eastward for a few miles in a comparatively low country. It then cuts ^{Sections on} through some prominent and partly wooded hills, which constitute the southernmost of the well marked foot-hill ridges, after which it flows northward for some miles before resuming its eastward direction. On the upper part of Pincher Creek the dips are generally south-westward, and the rocks exposed are for the most part sandstones, though where good sections occur shales are also seen. Two important bands of dark ^{Shale bands.} Pierre-like shales were, however, observed to cross the valley, one immediately west of the hills above alluded to, the other in a minor hollow in these. The first of these bands was again seen on the north branch of the Drywood Fork of the Waterton, and probably also runs through to Mill Creek. From Nelson's house, for about a mile down stream or to the road-crossing, strata composed of alternating grey, yellowish and greenish-grey sandstones and shales are almost continuously exposed, with a north-eastward dip of about 25°. These rocks evidently represent the St. Mary River sub-division of the Laramie, and extensive collections of well-preserved Laramie fossils have been made in them by Messrs. McConnell and Weston. Almost exactly at the road-crossing these are followed in ascending order by the reddish and ^{West edge} purplish-grey beds of the Willow Creek sub-division, with their char- ^{Willow Creek series.}

acteristically soft and massive appearance. A short distance below the road-crossing, they are found dipping in the same direction at an angle of about 15° , and gradually flattening out.

Sections at
Indian farm.

The upper beds of the St. Mary River sub-division here form the front of a wide low ridge or plateau which runs south-eastward, while the wide valley to the north-east of it is based on the soft Willow Creek beds. Seven miles south-eastward, at the Indian Farm, the edge of this plateau is cut into by a small brook which displays fine sections of the St. Mary River sub-division, extending downward from near the base of the Willow Creek beds. At the farm building the dip is N. 50° E. $< 20^{\circ}$, but gradually and pretty regularly increases, till at about a mile up the stream it reaches an angle of 54° . About one hundred feet beyond this point, a seam of coal occurs, and the beds become absolutely vertical, but this disturbance is shown to be local by the fact that at about an equal distance still further up the valley the beds resume their former direction of dip at an angle of 60° . This coal, where exposed, is excellent in quality, though much broken and slickensided, so as to crumble easily on handling. (See p. 29 M.) The seam where examined was two feet in thickness. The opening made on it had, however, fallen in at the time of my visit, but the seam was said to be considerably thicker a few feet into the bank. The coal is seen to be underlain by one hundred feet of yellowish beds, chiefly sandstones, and overlain by grey sandy shales and sandstones. It must occupy a position very near the base of the lower or St. Mary River sub-division of the Laramie, and the rocks of this sub-division here shown have an approximate minimum thickness of 2,700 feet.

Continuation of
seam.

As stated in the preliminary report before referred to, this seam should outcrop about a mile above the road-crossing on Pincher Creek, or near Nelson's house. The rocks at this place are, however, for the most part concealed. It is very probably the continuation of this seam, which has since (1883) been discovered in a coulée which opens into Pincher Creek, in the vicinity of the road-crossing.

Mill Creek.

On the upper part of Mill Creek, the beds, so far as examined, resemble those above described on the corresponding portion of Pincher Creek, and show general south-westward dips. About four miles above the mill, an excellent coal-seam occurs, of which, owing to the disturbed character of the rocks, the horizon has not been precisely fixed. It contains, according to Mr. Hoffmann's analysis (p. 40 M.) 1.63 per cent. of hygroscopic water and 12.37 of ash. The following sections of the seam, on opposite sides of a break or fault which here traverses the measures, are quoted from the preliminary report:—

Coal-seam.

DAWSON.]

At the dipping S. lain by a ish- and b little doub yielded a n examined. The Sou point at wh A few note a considera page. The Kootanie P house. A Brook) her exposed, th stone, is tw shales and one foot fiv pears to be On the ma point, dark the banks, shales are, that the roc of the Sou composed o

	FEET.	INCHES.
Coal (rather shaly)	3	1
Coal	2	0
Shale	1	4
Coal	2	0
Shale	1	4
Coal	2	0
Total coal.....	9	1

	FEET.	INCHES.
Coal (rather shaly).....	2	0
Shale	1	0
Coal (apparently good throughout, with the exception of a few shaly partings not equalling four inches in all	6	0
Total coal	8	0

At the mill, several hundred feet of hard blackish shales appear, Shales at mill. dipping S. 20° W. < 50°. These are probably Pierre, and are overlain by a series of grey and brownish-grey sandstones, and greenish- and bluish-grey shales which are nearly vertical. These, with little doubt, belong to the St. Mary River sub-division, and have yielded a number of species of fossil plants which have not yet been examined.

The South Fork of the Old Man, issues from the mountains at a South Fork of Old Man. point at which the continuity of the outer limestone range is broken. A few notes on the Cretaceous and Laramie rocks which here occupy a considerable area in the mountain country, are given on a succeeding page. The point which may be called the entrance to the North Kootanie Pass is at about two miles and a half south-west of Garnett's house. A small stream from the north (locally known as Kootanie Brook) here enters the South Fork. In its banks two coal-seams Coal-seams. are exposed, the upper, overlain by about twenty feet of massive sandstone, is two feet ten inches thick. Below it is about thirty feet of shales and sandstones of general dark colour, and then a second seam one foot five inches thick. The dip is S. 45° W. < 20°. The coal appears to be of very fair quality, and may prove of some local value. On the main stream, for a distance of two or three miles below this point, dark shales resembling those of the Pierre group characterize Wide shale band. the banks, and appear to underlie the beds containing the coals. The shales are, however, evidently repeated by folding, and it is possible that the rocks are in some places overturned. Just above the junction of the South Fork with Mill Creek, the stream is hemmed in by cliffs composed chiefly of greenish-grey sandstones with some shales.

West edge of
wide synclinal.

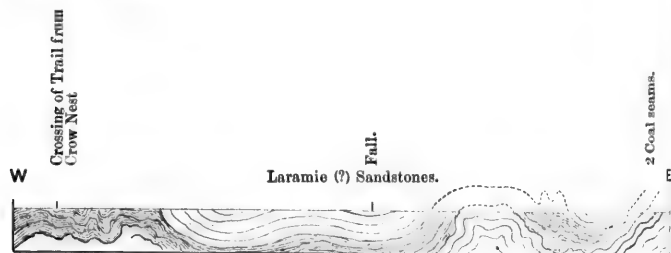
Between the point last described and that at which the base of the Willow Creek sub-division crosses the South Fork—about four miles eastward—a thin seam of coal is reported to outcrop in the bank, but was not visited. The appearance of the Willow Creek beds above referred to, may be regarded as constituting the western edge of the Porcupine Hill synclinal.

Middle Fork of
Old Man.
Gap in
Palaeozoic
range.

The gap through which the Middle Fork of the Old Man, or Crow Nest River, leaves the limestone ranges, appears to be connected with a remarkable change in the strike of the limestones, which amounts to about 40° in direction. The limestones on the south side of the gap dip nearly south-westward, while those to the north dip more nearly west. The inclination in both cases is from 40° to 45° . The eastern junction of the limestones with the Cretaceous rocks is probably a faulted one, and is accompanied by considerable disturbance. The dip of some of the beds of the latter formation nearest the limestones is nearly in the same direction with that of the limestones, but at a lower angle. From this point south-eastward to the crossing place of the Middle Fork by the Crow Nest Pass trail, the valley crosses the strike of the Cretaceous or Laramie rocks obliquely. The south-westward dips continue, and the rocks observed are chiefly greenish-grey sandstones, which often

Conglomerates.

weather brown, and are occasionally shaly. Near the first large tributary from the north which is crossed after leaving the limestones, the sandstones become for a considerable thickness conglomeritic. The pebbles are largely cherty materials from the limestone series, but also include many quartzite rocks probably derived from an underlying series not now seen in the mountains in this vicinity, together with a few porphyritic pebbles of a kind not yet observed in place in any part of the range.



Pierre shales. Horizontal scale 2 miles to 1 inch.
GENERAL SECTION ON MIDDLE FORK OF OLD MAN RIVER EAST OF CROSSING OF
TRAIL FROM CROW NEST PASS.

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8. Grey
9. Coal
10. Soft
11. Grey
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15. Coal
16. Carb
17. Grey
18. Ferr
19. Gree
20. Grey
21. Green
22. Sand

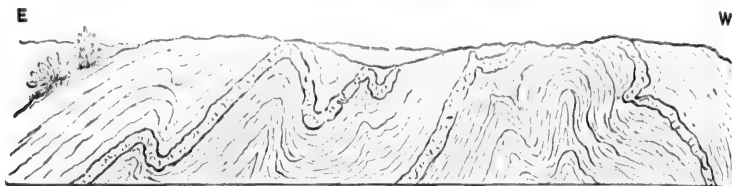
Near the trail-crossing above referred to, dark shales begin to occupy the banks of the valley, and continue with little interruption for a distance of nearly two miles. These shales are probably of Pierre age, and are many times folded together. Their position corresponds with that of a low tract of country which here stretches across to the South Fork. Eastward they are followed, apparently in ascending order, by a series of rocks which are chiefly sandstones, and may probably be Laramie. These extend, with undulating dips at low angles, for about three miles along the stream, or to a point about half a mile below the fall. The fall is about thirty feet in height, and occurs over massive grey sandstone beds, which are at this place nearly horizontal. These sandstones are interrupted to the east by a narrow band of black shales, which appears to fold over a compressed anticlinal of sandstone beds to the east, where the shales are again found, but with a thickness apparently much greater than before. This appearance is doubtless due to a series of repetitions by folding. They eventually take an eastward dip and form a small synclinal, the axis of which is occupied by yellowish and pale beds chiefly sandstones. On the east side of the synclinal the rocks above described as forming a compressed anticlinal, reappear, and at this point,—about four miles above the junction of the Middle and North Forks,—contain two good coal-seams. The following section, which extends downward from the base of the dark shales, was in part given in the preliminary report:—

	FEET.	INCHES.
1. Yellow-weathering sandstones and sandy shales.....	860	0
2. Dark shales, with a few thin sandstone layers.....	380	0
3. Grey to black, very fine shale, with occasional small fish scales and bones, becoming sandy and yellowish at base	6	0
4. Ferruginous sandstone.....	0	6
5. Greyish, soft sandstone or arenaceous clay, with some thin ironstone layers.....	10	0
6. Harder, greyish and ferruginous sandstone, with some obscure plant fragments.....	6	0
7. Hard, flaggy, yellowish sandstone	2	0
8. Grey, sandy shale and shaly sandstone.....	3	0
9. Coal.....	3	0
10. Soft, black carbonaceous shale.....	0	9
11. Grey, sandy shale.....	3	6
12. Grey, sandy shale and sandstone.....	4	6
13. Grey, flaggy sandstone, weathering rusty.....	2	6
14. Grey, sandy shale and shaly sandstone.....	5	0
15. Coal. Imperfectly seen, but at least 3 ft. of good quality	3	6
16. Carbonaceous shale.....	1	0
17. Grey, sandy shale.....	4	0
18. Ferruginous sandstone.....	0	6
19. Greenish-grey sandstone	10	0
20. Grey and blackish carbonaceous shale.....	4	0
21. Greenish-grey, soft-sandstone.....	6	0
22. Sandstone and arenaceous and carbonaceous shale, general greenish-grey tints, (about).....	80	0
	1395	9

Rocks at fall.

Flexures below fall.

Coal-seams.



CONTORTED SHALES AND SANDSTONES IN BANK OF MIDDLE FORK OF OLD MAN RIVER.

Wildly contorted rocks.

For some distance below this point the beds shown on the Middle Fork are so much disturbed and contorted that no attempt was made to work out their structure in detail. The accompanying sketch-section of some of the beds in this vicinity, illustrates the extent to which flexure has been carried in some parts of the foot-hill belt. At the last stream which joins from the north before the North Fork is reached, the Willow Creek beds appear in a nearly vertical attitude, and are followed eastward by beds which probably belong to the next overlying, or Porcupine Hill sub-division, and which on the lower part of the North Fork are found dipping regularly eastward into the high land of the Porcupine Hills.

Rocks between Middle and North Forks.

An attempt was made to trace out the belts of dark shales and those characterized by sandstones, in the foot-hills between the Middle and North Forks, and though this might doubtless be accomplished by the expenditure of sufficient time, it has not yet been fully effected. The shaly belts generally exist as anticlinal or synclinal folds more or less complex, which in some instances disappear by running beneath the sandstones of the highest tracts or slope up till they pass above the plane of the surface.

Remarkable valleys.

The most remarkable feature of this part of the foot-hills, is the existence of several wide valleys occupied by very inconsiderable streams, which nevertheless cut across the ridges at right angles to their strike. These can scarcely be explained except on the supposition of the occurrence of a number of parallel lines of fracture.

North Fork of Old Man.

The North Fork of the Old Man River, leaves the mountains near Lat. $49^{\circ} 52'$, and after running a little south of east about thirteen miles, bends more to the south, and runs parallel with the western flank of the Porcupine Hills.

West Edge Porcupine Hill synclinal.

Near the bend, good sections of the Willow Creek series occur, the beds dipping to the east at an angle of 12° . Half a mile further up the stream, they are underlain by the more massive and harder sandstones and shales of the St. Mary River sub-division, which dip at first to the east at an angle of about 15° , but soon become vertical and even slightly overturned in places.

Near the centre of this band, which is about one mile and three-

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quarters wide, nine hundred feet of clays and sandstones resembling the Willow Creek series occur. The next rocks seen are shales belonging to the Pierre formation. These shales are somewhat sandy, and alternate at intervals with a thick bed of bluish sandstone. The dip is nearly vertical. They are succeeded by a great series of thickly bedded bluish and grayish sandstone, alternating with more thinly bedded sandstones and with greenish and dark shales, the whole forming a band about a mile and a half wide.

The remainder of the section is occupied by alternating bands of sandstones and shales almost exactly similar to the two just described, the dip is usually to the west at angles varying from 60° to vertical and the strike about N. 25° W.

Near the mountains the sandstones lie at lower angles and enclose Coal-seam. a few beds of conglomerate and a coal-seam four feet thick and of excellent quality. (See p. 33 M.)

The band of dark shales next the mountains on this section, is very much flexed and crumpled, and is underlain by about forty feet of greenish and bluish sandstones and whitish quartzites, and these overlie, apparently quite conformably, the Palaeozoic limestone. The dip of the limestone is, in this instance, at first eastward at an angle of about 30° , but in about seventy-five yards, it folds over an anticlinal and dips in toward the mountains.

HIGHWOOD RIVER, SHEEP CREEK, ELBOW RIVER.

The following descriptions of the rocks on the Highwood River, Sheep Creek and the Elbow River are by Mr. McConnell, and are illustrated by the accompanying sheet of sections.

"Highwood River affords the best section through the foot-hills of any of the streams flowing from the mountains between Bow River and the 49th parallel. Highwood River.

"From the mouth of a coulée running into it, about eight miles west of the fifth principal meridian, where the disturbance of the beds first becomes well marked, on to within a short distance of the mountains, it flows in a deep cañon-like channel, the sides of which afford almost continuous sections of the nearly vertical sandstones and shales characteristic of this region. The width of the disturbed area on Highwood River is about eighteen miles, though the rocks undulate slightly for seven or eight miles more.

"Going up Highwood River from the crossing of the Calgary trail, good sections of rock appear at all the principal bends of the stream. These are of the usual character of the rocks belonging to the St. Mary River sub-division, consisting of sandstones and clays. A thick band of yellowish-weathering sandstone is a prominent feature in many of the Laramie rocks.

sections. Highwood River forks about six miles west of the fifth principal meridian, after which the valley of the main stream bends to the north, and gradually assumes the character of a cañon.

Sections near
lower forks.

"The Southern Fork branches again about two miles further west, and one of the streams bending to the south runs parallel with the Porcupine Hills, while the other continues westward to the mountains. Neither of these streams have valleys at all comparable in size or geological interest with the valley of the North Fork, and exposures of rock in them are very infrequent. In one place the valley of the Middle Fork almost disappears, the stream being depressed but very little below the general surface of the country.

"Near the lower forks, good sections of sandstones and clays occur, the rocks dipping westward at a low angle, which gradually increases further up the stream. Three miles further on, some carbonaceous seams appear in the section, and near them some fresh-water shells were found. A mile and a half up stream from this point, the rocks become for the first time suddenly and violently disturbed. They are thrown into an almost vertical position, and for a short distance resemble in the complexity and sharp plications of the subordinate folds the gneisses of the Laurentian system. The strike of these rocks is about N. 18° W., and following this direction northward the next transverse section that is met with is that of the South Fork of Sheep Creek, distant about twelve miles, but the rocks appearing in it do not belong to the same horizon, but to the underlying Pierre shales, showing that the disturbed rocks on Highwood River must mark the axis of an uplift which a little farther north has broken apart the rocks of the St. Mary River sub-division, and brought the Pierre shales to the surface. The contorted rocks on Highwood River consist of sandstones and shales, and include three small coal seams, all so crumpled as to be almost worthless. They also include an oyster bed composed of shells of an *Ostrea*, which is probably *O. glabra*.

Crumpled coal
seams.

"From this point the river runs in the strike of the rocks about three miles, then bending more to the west, cuts across them.

"The rocks continue highly disturbed for several hundred feet across their strike, then the contortions gradually die away, and the strata dip regularly eastward at a high angle, until they are replaced by the Pierre shales. The rocks appearing in the section above the disturbed area consist of sandstones, in beds varying in thickness from six to thirty, and even fifty feet. The softer beds are usually of bluish and greenish colours, and the harder, yellowish or brownish, the different beds being separated by greenish and dark-colored shales and clays.

"Succeeding, and underlying the rocks just described, is a great thick-

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ness of dark shales. These at first dip to the east at an angle of about 50°, but soon become vertical, and dip westward before being replaced by sandstone. This series has the form of a simple sharp anticlinal, and measures about a mile across its strike, which would give it, if uninfluenced by local folds or by faults, a thickness of at least 2,000 feet. A section measured at the eastern outcrop of these rocks gives:

	FEET.
Sandstone.....	..
Black shales.....	75
Sandstone, weathering bright yellow.....	30
Alternating sandstone and shale.....	75
Black shale

"The sandstone bed appearing in this section, although traceable along its strike for over a mile, does not appear at the other side of the anticlinal, nor at any intermediate point, which seems to show that the great thickness of these beds is not due to repeated folding.

"The next rocks in the general section are heavily bedded sandstones lying on top of the shales, and dipping westward at a high angle. These sandstones differ greatly in every respect from the rocks east of the shales, they are harder and firmer in texture, much more heavily bedded, and the colors are green, red and brown in place of bluish and yellowish. These beds undulate a couple of times without bringing any other rocks up, and are then followed by a series of thinner and more argillaceous beds, alternating with beds from ten to twenty feet thick and with a thin band of shale about one hundred feet thick, the whole undulating in a succession of sharp folds for several miles. A thick bed of greenish sandstone underlying the shales can be traced through several of these folds. North of Highwood River, on Sheep Creek, in the exact strike of this series of alternating sandstones and shales, scarcely any sandstone is found, the shales occupying the entire section. West of the rocks just described, the valley of the river is occupied for several miles by an immense thickness of almost vertical shales. These shales are hard, in some places almost passing into slates, and are very dark in color. They are interstratified in places with thin bands of rather hard flaggy sandstone, but none of these bands could be identified a second time.

"This band of shales was traced northward across Sheep Creek and Fish Creek to the Elbow River, and southward to Willow Creek, a distance of over fifty miles. In some parts of its course its direction is marked by a wide valley, but more frequently the harder sandstone bands included in it project above the surface, forming hills and ridges.

"Between the band just described and the mountains, the shales re-appear six times in bands varying from one-fifth of a mile to a mile and a quarter in width, their general character being much the same in all. They dip to the west at a very high angle, being often vertical, and occasionally even overturned.

Character of
sandstones.

"The sandstones alternating with the shales vary greatly both in texture and colour, but they may be generally described as consisting of thick beds, greyish or bluish on a fresh fracture, but often weathering yellowish or brownish. These alternate with bands consisting of more thinly bedded sandstones, and greenish or reddish, and reddish and dark shales, the thick beds of sandstone standing prominently out on the sides of the valley, and the softer rocks separating them being concealed. Near the mountains these sandstones form hills which rise 2,000 feet above the valley.

Coal-seam.

"In the last appearance of the shales near the mountains they hold a coal seam about two feet thick.

"A small stream falling into Highwood River about eight miles from the mountains, gives a very good section of rocks parallel with the section on Highwood River, and distant from it from four to five miles, the only noticeable difference between the two sections being the division on the creek of one of the bands of shales, and the appearance of an additional band of sandstone. Near the mountains, the sandstones lie at lower angles than on Highwood River further east, and several beds of conglomerate appear.

Sheep Creek

"On Sheep Creek the disturbed rocks are about twenty-five miles wide, and are remarkable for the large proportion of shales which they contain.

"These shales first appear about ten miles west of the fifth principal meridian, forming a sharp anticlinal, the dip at both edges being about 50°. They are succeeded by about half a mile of sandstone, dipping west at a high angle, and then the shales again come in and occupy fully nine miles out of the next ten of the section, the dip being to the west at angles varying from 50° to vertical. These shales resemble in every respect, except in width, the shales seen on Highwood River. They are succeeded by several smaller bands, which alternate with bands of sandstone of about an equal size.

Elbow River.

"Near the mountains the sections on Sheep Creek, owing to the almost impassable character of the country, were not examined.

"The Elbow River affords in its upper part a good section of the rocks near the mountains which there as elsewhere consist of alternating bands of sandstone and shales, the sandstones however being more

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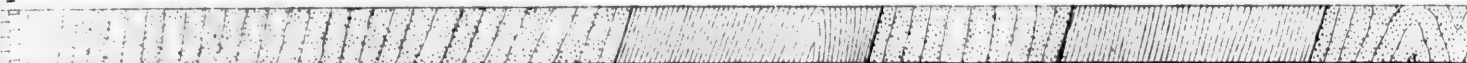
(1) Section on the Elbow River in the Foot Hills.

A



1st PALAEOZOIC ROCKS OF MOUNTAINS.

(3) Section through the Foot Hills of



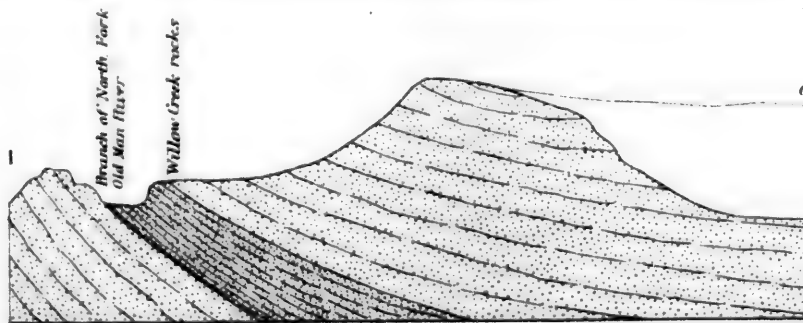
G EASTERN EDGE

(4) Section through the Foot Hills on the North Fork of

Conglomerate
Coal seq. 3 mi.
North Fork 4' 0"



Shales much disturbed



SECTIONS ILLUSTRATING THE

28 Miles West of
The Elbow

B

(2) Sec

C

Foot Hills on the Highwood River from a point about four miles West of the Forks to the base of the

North Fork of the Old Man River.

Near Southern Bend
of North Fork

H

Willow Creek rocks

EASTERN EDGE DISTURBED BELT.

Sections 1-4 Horizontal Scale 1 mile to an inch.

(5) Barometric Section across the Porcupine Hills.

General outline summit of Plateau

Porcupine Hill series (chiefly sandstones)

Horizontal Scale 1 mile to 2 inches.
Vertical Scale 2000 feet to 1 inch.

ILLUSTRATING THE CRETACEOUS AND LARAMIE ROCKS OF THE DISTURBED BELT AT THE BASE OF THE MOUNTAIN

From measurements by R. G. Mc Connell, B.A.

(2) Section on Sheep Creek in the Foot Hills.



s to the base of the mountains.



5 Miles
West of Forks

rocks

DISTURBED BELT.

NOTE. Owing to the want of Paleontological in character of the rocks in the vicinity has been made to indicate the various subdivisions of the Laramie on these sections, which therefore lithological character and sequence of the



Willow Creek rocks

Willow

OF THE MOUNTAINS, AND THE PORCUPINE HILL SYNCLINAL.

14 Miles West from
crossing of Calgary Trail

D



5 Miles
West of Forks
Coal seam
1'-6"

F



EASTERN EDGE DISTURBED BELT.

Much disturbed

to the want of Palaeontological evidence and variability
the rocks in the vicinity of the mountains no attempt
indicate the various subdivisions of the Cretaceous and
sections, which therefore represent only the general
character and sequence of the rocks as actually observed.



Sandstones



Shales (generally dark)



Limestone

J

Willow Creek



NOTE. The lines in these sections
represent observed dips and not
actual beds.

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SECTION

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SECTIONS ON THE BOW RIVER IN THE FOOT-HILLS.

The foot-hills west of Morley, in the vicinity of the Bow, cease to present the narrow ridge-like and parallel forms generally characteristic of them, and become broad-topped and rounded. This is in connection with a change in the attitudes of the Cretaceous and Laramie beds of which they are composed, which here depart from the parallelism in strike to the base of the mountains which they usually maintain, and in some cases—as immediately below the fall—turn at right angles to their former direction and become occasionally nearly horizontal. West of the fall, (which is nearly in a line with the general direction of the edge of the Palæozoic) the Cretaceous or Laramie rocks form a bay in the edge of the limestones, of which the river occupies the centre. The dips are quite low, and as usual toward the mountains, and it would appear that the limestones are folded back over the newer rocks.

On the Kananaskis, a short distance above its mouth, dark Pierre-like shales with numerous bands of red-weathering ironstone, are well exposed. Immediately below the confluence of the Kananaskis the fall above referred to occurs, the beds producing it being a series of massive sandstones with light westward dip. These are followed and apparently underlain by, a considerable thickness of shales.

From this place, following the Bow to a point three and a half miles below the Ghost River, there are numerous fine exposures in the banks, but as these have not been examined in detail or measured, no connected description of them need here be attempted. As a whole, the rocks appear to consist of a very thick series of dark shales with some sandstone intercalations and a few beds which become conglomeritic. The shales appear to lie between two series of rocks characterized by pale tints and a predominance of sandstones, one of which doubtless represents the Laramie. At the point above defined, below Ghost River, the shales are seen for the last time, and are followed by sandstones

Peculiar character of foot-hill region on Bow.

Rocks near fall.

Shale and sandstone bands.

* The above paragraph, by Mr. McConnell, refers to the first section of the folding sheet, and carries the description westward to a point about thirty-seven miles above "The Elbow." Beyond this point lies a region of broken and very rugged hills which has since (in 1884) been partly explored, and regarding which the following preliminary note may be added.—It would appear that the limestone above mentioned constitutes merely an outlying ridge, and that before the limestone ranges are finally reached at a further distance of about ten miles, several anticlinal and synclinal folds are crossed—the former constituting limestone ridges, the latter troughs of Cretaceous. The arrangement of these, so far as determined, is shown on the map, and it is even possible that the western trough may connect north-westward with the continuation of that on which the anthracite deposits of Cascade and Bow River are situated. The surface of the country is here, however, near the base-level of the Cretaceous formation and the plication has given rise in consequence to an intricacy of outline which has not yet been thoroughly worked out.

and sandy shales which, with little doubt, represent the base of the Laramie, though much disturbed and sharply folded. At the mouth of Coal Creek these beds assume a regular eastward dip, and this may be regarded as the western edge of the wide Porcupine Hill synclinal. The rocks occurring on the Bow River below this point have been noticed on a previous page. (p. 80 c).

CRETACEOUS AND LARAMIE ROCKS IN THE MOUNTAINS.

That portion of the Rocky Mountains near the 49th parallel, which was examined in connection with the Boundary Commission expedition in 1874, is composed entirely (with the exception of remnants of Triassic rocks) of Palaeozoic strata, and the line between these and the newer formations of the plains is there perfectly distinct. It was, however, discovered, in the autumn of 1881, that a considerable area of the newer rocks occurs on the North Kootanie and Crow Nest Passes within the line of the eastern limestone range. Some time was devoted to the examination and outlining of this area in 1883,* and much information regarding it obtained. This will properly form a part of a succeeding report on the Rocky Mountains, it is thought well to give here a few notes on this area, which, on account of the occurrence of several good coal-seams, and the fact that the lower hills characterizing it bear a much more considerable quantity of good timber than other portions of the mountains, appears to possess considerable economic importance. The outlines of this area are also in part shown on the accompanying geological map.

Notes here
given
preliminary.

The notes here given with regard to this area are, however, merely of a preliminary character, and refer chiefly to the position of the coal-seams. These, though rather inaccessible as sources of supply for the country in general, will in event of the discovery of metalliferous deposits, assume immediate importance for smelting purposes, particularly as they are generally of excellent quality.

Extent of
trough.

The area of Cretaceous and Laramie rocks extends from the Little South Fork, or south branch of the South Fork, to the sources of the North and North-west branches of the North Fork, and thence (according to the exploration of 1884) to the head-waters of the Highwood River and Sheep Creek.

The country underlain by this trough of Cretaceous and Laramie rocks, resembles orographically and geologically the rougher portions of the foot-hill belt, already described. It is over ninety miles in extreme length, and in its southern part averages about ten miles in width, with a total area probably exceeding 750 square miles. It is

* The explorations of 1884 have since added largely to our knowledge of this and other troughs of Cretaceous and Laramie rocks in the mountains.

separated from the eastern limestone map. As already this range, through proper. This app North Branch the

On the South Fork afforded by the eastern beds have been much disturbed than they are the Middle Fork of the turbid, and generally are in an intermediate

With one exception rocks of this area are of sandstones of various argillaceous shales, a series of dark shales. Cretaceous fossils here glomerates are not Cretaceous and Laramie line, or at least where supply material of is the existence of volcanic origin. The glomerates or ash which appear to have of this part of the series colour from purple characteristic and up Crow Nest Pass, within many miles north and west of the Livingstone these rocks were apparently dying out, appear three times folding, but are here Nest Pass.

The occurrence of Kootanie Pass has above the mouth of important coal-seams through which the

separated from the foot-hills, for the greater part of its length, by the eastern limestone range, named the Livingstone Range on Palliser's map. As already stated, however, there is a wide gap to the south of this range, through which this area inosculates with the foot-hills proper. This appears to occur also at one other point, where on the North Branch the limestone range is again interrupted for a few miles.

On the South Fork, probably owing to the absence of the protection ^{Folding of beds.} afforded by the eastern limestone range, the Cretaceous and Laramie beds have been much more closely folded together and are more disturbed than they are elsewhere generally found to be in this area. On the Middle Fork or Crow Nest River, the beds are remarkably undisturbed, and generally lie at low angles, while on the North Fork, they are in an intermediate condition in respect to folding and disturbance.

With one exception, no marked difference is found between the ^{Character of rocks.} rocks of this area and those of the foot-hills. They consist principally of sandstones of varied degrees of induration, interbedded with sandy argillaceous shales which are often greenish- or bluish-grey, and a series of dark shales with sandstone intercalations, from which marine Cretaceous fossils have been obtained, recur in a number of places. Conglomerates are not unusual, and it is evident that the deposition of the Cretaceous and Laramie rocks here occurred in proximity to a shoreline, or at least where insular masses of the older rocks were at hand to supply material of a coarse character. The exception above alluded to ^{Contemporaneous volcanic deposits.} is the existence of an important intercalated series of bedded rocks of volcanic origin. These are for the most part coarse or fine-grained agglomerates or ash beds which have been arranged by water, but beds which appear to have been trappean flows are also found. The rocks of this part of the series are generally hard and compact, and vary in colour from purplish to greenish-grey, though the latter tint is most characteristic and universal. These rocks have a great thickness on the Crow Nest Pass, where they form a prominent ridge which runs for many miles north and south, and crosses the stream about seven miles west of the Livingstone or eastern limestone range. To the north, these rocks were again seen, but in very inconsiderable thickness, and probably dying out, on the North-west Branch of the North Fork. They appear three times on the South Fork, being repeated by the excessive folding, but are here again much less in thickness than on the Crow Nest Pass.

The occurrence of two thin coal-seams at the entrance to the North ^{Coal-seams on South Branch of Old Man.} Kootanie Pass has before been referred to (p. 99 c). About four miles above the mouth of the Little South Fork, on the main river, an important coal-seam outcrops in the rocky banks of a small cañon through which the stream here flows. The beds are folded into a nar-

row synclinal, and there is some appearance of irregularity in the measures. The principal coal-seam is nine feet nine inches in thickness. It is underlain by eight inches of shale, below which is a second seam fourteen inches in thickness. These seams are capable, together, of yielding about ten feet of clear coal, and the quality appears to be excellent.

Coal-seams in
Crow Nest Pass.

On the Crow Nest Pass, three miles west of the Gap, or western edge of the first limestone range, a considerable brook flows in from the north. Half a mile above the trail-crossing of this stream, three coal-seams occur in a bank about forty feet in height, which is chiefly composed of brownish, greenish, and blackish-grey sandy shales, and is capped by a massive grey sandstone.

The highest seam is two feet thick, the next two feet ten inches, and the lowest, one foot five inches. They are separated by such a considerable thickness of shales as to preclude their being worked together, but the quality of the coal seems to be very good. The dip is S. 85° W. < 30°

Coal-seams on
North-west
Branch of
North Fork.

On the North-west Branch of the North Fork, coal was found in two places. One of these is at the point at which the stream changes its general direction from south-east to east, about two miles and a-half up from its mouth. The section in the right bank is here as follows:—

	FEET.	INCHES.
Superficial gravels		
Coal	1	0
Shale	0	1
Coal	2	6
Shale	0	4
Coal	5	6
Shale	0	6
Coal	0	9
Sandstone	2	0
Coal and shale	2	0
Black shale	1	6
Sandstone	2	0
Black shale, with coaly layers and some ironstone	9	0
Clay shales and ironstone (to water)	6	0
Total coal	9	9

This coal is, so far as composition goes, of good quality, burning with a long flame and coking, but has been much crushed by the movement of the rocks, and is traversed throughout by slickensided surfaces, so that it crumbles very readily.

The second locality is about ten miles further up this stream, near the water-shed range, and in a somewhat inaccessible place. The outcrop examined is half a mile below a picturesque waterfall. The measures

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are very much disturbed in the coal in the seam, the

The coal represents the Man, together with the Livingstone formation, that at the entrance not necessary to determine the same horizon, folding of the measures.

There is reason to believe that the Elk River, west of the mouth of the These, though exact report.

Thin coal-seams are found in Highwood and Shinarump. The geological arrangement of fragments of coal in the measures may be found in the North Fork and Jaramie within the same range. They have been discovered in the examination of this range.

No allusion is here made to the anthracite has been found in the of the railway line. The present report. The inclusion of the the inclusion of the which the disturbance far as to expel all Additional instances probably be found

ARRA

On a former page mention of the sub-district. The following formations of the district. The maximum age

* The discovery of the the northern edge of the joining area. It is not desirable to examine some of the bones indicate its age to be lower

are very much disturbed, but there appears to be about three feet of coal in the seam, though much crushed like that last described.

The coal represented at these localities on the head waters of the Old Man, together with that previously noticed on the North Fork east of the Livingstone Range (p. 103 c), that on the Middle Fork (p. 101 c), and that at the entrance to the North Kootanie Pass are, on various grounds, not necessary to detail at present, supposed to be on the same or nearly the same horizon in the Cretaceous rocks, it being repeated by the folding of the measures.

There is reason for the belief that the coals on the head waters of the Elk River, west of the water-shed range, again occupy the same horizon. These, though examined in 1883, lie without the limit of the present report.

Thin coal-seams have also been observed on the head waters of the Highwood and Sheep Creek, and it is probable, from the stratigraphical arrangement of the rocks and from the observation of rolled fragments of coal in a number of places, that natural outcrops of coal may be found in many additional localities, in this area of Cretaceous and Laramie within the mountains. Those above noted may be said to have been discovered by us almost accidentally, and the complete examination of this rough wooded region would occupy much time.

No allusion is here made to the trough of similar rocks in which anthracite has been found, which occurs on the Bow Pass in the vicinity of the railway line, as this again lies to the west of the area of the present report. This trough is, however, merely a special instance of the inclusion of the newer coal-bearing series in the mountains, in which the disturbance and consequent alteration have been carried so far as to expel almost all the volatile constituents from the coal. Additional instances of included areas of the newer rocks may also probably be found as the mountains are more fully explored.

GENERAL GEOLOGY.

ARRANGEMENT AND COMPOSITION OF ROCKS.

On a former page, a synoptical table has been given of the arrangement of the sub-divisions of the Cretaceous and Laramie of the district. The following scheme shows the sequence and character of the formations of the district in a more detailed form, with the approximate maximum ascertained thickness of each series.*

* The discovery of the Miocene area in the Hand Hills, of which a small portion appears on the northern edge of the map, is the result of work by Mr. J. B. Tyrrell in 1884, in the next adjoining area. It is not described in this report. Prof. E. D. Cope, who has been so kind as to examine some of the bones obtained from this formation in the Cypress Hills, reports that these indicate its age to be lower Miocene equivalent to the White River group.

Table of
formations.*Laramie.*

Porcupine Hill beds. Sandstones, frequently thick-bedded and generally comparatively soft, with intercalated greyish and blackish shales and shaly clays. Fresh water.—2,500 feet.

Willow Creek beds. Soft sandstones, shales, clays and sandy clays, generally with a pronounced reddish or purplish tint. Fresh water.—450 feet.

St. Mary River beds. Sandstones shales and shaly clays in frequent alternations, and generally well bedded. Fresh water except near base.—2,800 feet.

Cretaceous.

Fox Hill Sandstones. In some parts of the district well defined as a massive yellowish sandstone, but inconstant, and apparently often represented by a series of brackish-water transition beds between the Laramie and Pierre.—80 feet.

Pierre shales. Neutral grey or brownish to nearly black shales, include a zone of pale soft sandstone in the north-eastern part of district, and frequent intercalations of harder sandstones near the mountains. Marine.—750 feet.

Belly River series. Composed of an upper, or "pale" and lower or "yellowish" portions, and consisting of alternations of sandstones, sandy clays, shales and clays.—910 feet.

Lower dark shales. Gray to nearly black shales, frequently with arenaceous shales.—800 feet.

Thickness of
series.

The figures above given may be regarded as representing the greatest thickness observed in each case, but with the exception of the Pierre shales and Fox Hill sandstones, and possibly of the St. Mary River series and lower dark shales, the exposures from which the thickness was determined were not such as to show that the whole of the series in question was displayed, so that the actual volume may be greater. It should also be remarked that as the measurements given have been derived from different parts of this somewhat extensive district, it may be that the rocks do not show the development above indicated in any one locality. It is probable, however, that the total normal volume of the series included in the list does not fall short of that resulting from the addition of the above figures, viz., 8,290 feet, of which 5,750 feet would represent the Laramie and 2,540 feet the Cretaceous proper.

No
unconformity.

There is no evidence of disturbance or any unconformity greater than that caused by trifling local erosion throughout the whole of this great thickness of beds, the passage from one series to the next being frequently of so gradual a character as to leave the observer in some doubt as to the point at which the dividing line should be drawn.

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With regard to information can be obtained as to the existence, in the Willow Creek horizon, of the Laramie would have been attempted to be found in the northern part of the Hill beds are remains of further search will be made in which fossils of the Laramie there are no paleontological from the remainder of the Point," about two miles. The Willow Creek series to some extent by the district. The most typical is the Battle (p. 56 c) and though the beds in the Willow Creek are considerably indurated, the thickness of the locality is 190 feet, and the thickness of 450 feet was determined. The division is at least 100 feet. Usually seen in single beds, but in some subdivisions are also seen with the foregoing series. The reddish and purplish is their most characteristic layers which differ from the Willow Creek. The Willow Creek the mountains in the district of them occur in the district occurring on the upper Bow River this subdivision the Porcupine Hill series lost its distinctive character. It is little doubt, connect the red (probably Tertiary) occurred at the time of the fact that the series is continuous with the red beds in the mountains. The great part at least

With regard to the composition of the Porcupine Hill beds but little information can be given in addition to that above tabulated. But for the existence, in the southern part of the district, of the well marked Willow Creek horizon, the separation of these from the lower part of the Laramie would be impossible; and as previously stated, it has not been attempted to carry out on the map the subdivision of the Laramie in the northern part of the district. So far as examined, the Porcupine Hill beds are remarkable for the paucity of their organic remains, but further search will doubtless lead to the discovery of some localities in which fossils occur in greater abundance. So far as ascertained there are no paleontological grounds for a separation of these beds from the remainder of the Laramie. The fossil plants from "Shaganappi Point," about two miles west of Calgary, are from this subdivision.

The Willow Creek beds constitute a zone well defined by colour, and to some extent by physical character, in the southern part of the district. The most typical sections examined in detail are those of Belly Butte (p. 56 c) and of the upper part of the St. Mary River (p. 63 c), though the beds in the latter place are inclined at high angles and considerably indurated. The thickness measured at the first-mentioned locality is 190 feet, at the second 214 feet. On the Waterton, a thickness of 450 feet was actually observed, and it is probable that the subdivision is at least fifty feet greater. A thickness of 140 feet is actually seen in single banks on the Old Man River. The beds of this subdivision are also singularly poor in organic remains, and these (as with the foregoing subdivision) are so far as observation goes, confined to fresh-water molluscs, with the exception of a single chelonian. The reddish and purplish tint of many of the beds of this subdivision is their most characteristic feature, but these alternate with pale grey layers which differ from them in colour only.

The Willow Creek beds evidently extended well in to the base of the mountains in the southern part of the district, as narrow troughs of them occur in the disturbed belt. The section above referred to as occurring on the upper part of the St. Mary is one of these. On the Bow River this sub-division appears to be represented on both sides of the Porcupine Hill synclinal—as described on a former page—but has lost its distinctive colouring. The reddish tint of these beds is, with little doubt, connected in some way with a period of greater waste of the red (probably Triassic) beds of the Rocky Mountains, which occurred at the time of their deposition. This is rendered evident by the fact that the extension of the characteristic tint to the north is contemporaneous with that of the development of the above-mentioned red beds in the mountains; a fact which also tends to prove that a great part at least of the material of the Laramie was derived di-

rectly from the region of the present Rocky Mountain ranges on the west.

St. Mary River
beds.

The St. Mary River sub-division is characterized by more rapid alternations in lithological character; sandstones, which are often thin-bedded or flaggy, and shales and sandy shales being represented on the whole in about equal proportion. The sandstones occasionally weather to a yellow colour, but are more usually grey or greenish-grey and often quite hard. The shales and clays are of similar colours but often also carbonaceous. On the Waterton River, the thickness given in the foregoing table was ascertained, but fifty feet or more of the upper portion of the beds here measured may belong to the overlying sub-division, and the base was not seen. At the Indian farm these beds have an estimated thickness of 2,700 feet, and this probably comprises almost the entire volume there developed. On the west side of the Porcupine Hill synclinal, on the Bow, a thickness of about 3,300 feet of the lower part of the Laramie is shown, but of this a portion probably belongs to the Willow Creek beds.

The St. Mary River beds have yielded numerous remains of fresh-water molluscs, the richly fossiliferous beds described as occurring on the St. Mary and Pincher Creek (pp. 57c, 97c, 37c) belonging to a horizon in its upper part. It has also afforded dinosaurian remains, and contains beds of lignite or coal, particularly in its lower part. The coals found near the Indian farm and Coal Creek probably belong to this series, and a well defined lignite-bearing zone outcrops at Scabby Butte, on the Little Bow, Bow and Red Deer Rivers.

Extent of
Laramie.

The Laramie beds do not anywhere extend to the eastern edge of the map, and, with the exception of its northern part, are now represented only in its western half.

Fox Hill
sandstones.

The Fox Hill sandstones are well defined only in the south-western part of the district, crossing the St. Mary with a thickness of about 80 feet, as above indicated. These typical beds have yielded no fossils, but they may evidently be regarded as an upper portion of the Pierre, with the shales of which some sections show an inter-bedding. They are included under a single colour with the Pierre on the map. On the Old Man River at Rye-grass flat, at Scabby Butte and on the Little Bow, Bow and Red Deer rivers, the western outcrop of the Laramie is associated with a thick series of yellowish and greyish sandstones and sandy shales and clays, holding a brackish-water fauna and passing down into the Pierre. As the Fox Hill beds proper are not here developed, it is probable that these may represent that series in whole or in part, but as their fauna appear to ally them most closely with the Laramie, they have not been separated from that series. These beds are also displayed at a number of places in the disturbed belt west of the St.

Extensive
brackish-water
transition
series.

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Mary and south of they contain are Co and a large rough dinosaurian and ch also occur, and the near the Boundary to it. At one place brackish-water or observed in a single

A thickness of 84 flat, and they form McConnell to overti

The Pierre shales stant, and may be re the entire district. their total volume h they are 750 feet in occasional layers hi served in the layer There is reason to be the entire section—a Ridge.

On the Old Man R series, for a thickness sandy shales in very ness. North-eastwar to a thickness of 135 direction, on the Red large part of the wh ferruginous layers a sandy beds. The Pi lignite-coal, but this series on the Bow is probably 50 feet or m

Wherever the botto terized by a carbonac are frequently of worl Belly River and are ill includes alternating different in character ing *Ostrea subtrigonalis* of *Unio* have been obs

Mary and south of the Old Man. The most characteristic forms which they contain are *Corbicula occidentalis*, *Corbula* n. sp. like *C. pyriformis*, and a large rough *Ostrea*. At Scabby Butte they yield fragmentary dinosaurian and chelonian remains in great abundance. Coaly zones also occur, and the coals at the Indian farm and on the St. Mary River near the Boundary line are near this horizon and may possibly belong to it. At one place on the Bow (p 84 c) the passage upward from brackish-water or marine conditions to fresh-water may actually be observed in a single section.

A thickness of 840 feet of these beds was measured at Rye-grass flat, and they form a portion of the 990 feet of beds observed by Mr. McConnell to overlie the Pierre on the Red Deer.

The Pierre shales are as a whole remarkably characteristic and constant, and may be regarded as forming the key to the stratigraphy of the entire district. The only place in which a satisfactory estimate of their total volume has been obtained is on the Red Deer River, where they are 750 feet in thickness. They are marine throughout and in occasional layers highly fossiliferous, the fossils as a rule being preserved in the layers or nodules of ironstone, which are abundant. There is reason to believe that these shales—and probably the rocks of the entire section—are abnormally thin in the vicinity of Milk River Ridge.

On the Old Man River below Rye-grass flat, the upper portion of the series, for a thickness of about 40 feet, is composed of coffee-coloured sandy shales in very regular beds each of a few inches in thickness. North-eastward, on the Bow, these peculiar beds have increased to a thickness of 135 feet or rather more, and still further in the same direction, on the Red Deer, have a volume of 500 feet and constitute a large part of the whole series. These beds include red-weathering ferruginous layers and also, in the last-mentioned locality, greyish sandy beds. The Pierre on the Bow is capped by a good seam of lignite-coal, but this was not seen elsewhere. Near the base of the series on the Bow is a zone of pale soft arenaceous beds which is probably 50 feet or more in thickness.

Wherever the bottom of the Pierre has been observed, it is characterized by a carbonaceous horizon, yielding coals or lignite-coals which are frequently of workable thickness. These are best developed on the Belly River and are illustrated in the sections facing p. 72 c. This horizon includes alternating greyish and blackish shales and arenaceous beds different in character from the typical Pierre shales. In it a bed holding *Ostrea subtrigonalis* in great abundance, with occasional fragments of *Unio* have been observed at the mouth of the St. Mary and at Milk

River Ridge. It evidently constitutes a series of passage beds between the Pierre and the next underlying series.

Pierre shales
near mountains.

Near the mountains, the Pierre shales become much more arenaceous and include many beds of sandstone, which in a few places become actual conglomerates, and there is every evidence of approach to a shore-line in this direction. This renders the definition of the Pierre in the disturbed belt additionally difficult, and it is besides often impossible in this region to know whether a given shaly zone belongs to this or the lower shaly series.

Upper portion
of Belly River
series.

The pale upper portion of the Belly River series is well shown on the Belly above Coal Banks, and a typical section of a portion of it in Fossil Coulee, Milk River Ridge is described on page 50c. It is composed for the most part of sandy clays, with shales and sandstones, the latter often of considerable thickness, and usually rather soft, or irregularly hardened. Layers of ironstone nodules, which are at times very large, are of frequent occurrence, and the beds generally have a characteristic bluish- or greenish-grey tint, and are on the whole rather massive, and weather easily into bad-lands. In these features, with the occurrence of rolled clay pellets, and the rounded character of many of the included bones, there is evidence of a considerable amount of current or wave action.

* In Fossil Coulee, a thickness of 123 feet of this part of the Belly River series was observed; on the Old Man River above Coal Banks, at least 200 feet; on the Red Deer River at least 460 feet.* On the Milk River east of the area of the present map at least 360 feet, and by Mr. McConnell on the South Saskatchewan (also east of the map) at least 400 feet. This and a part of the lower or yellowish portion of the same series are represented still further east by the section measured by me near the East Fork of Milk River.†

Fossils and
coals.

Near the top of this upper pale portion of the Belly River series, marine or brackish-water molluscs are occasionally found, but it must be considered on the whole as a fresh-water formation. Molluscs are, however, everywhere rather rare, though dinosaurian remains are in some places moderately abundant (See p. 38 c). At the base of this portion of the series, or near the summit of the next, a carbonaceous zone occurs on the Bow, Belly and South Saskatchewan Rivers. The lignite-coals of these somewhat widely separated localities may not represent a single seam, but are in all probability not far from one horizon. On the Red Deer two seams of lignite-coal occur which appear to be some distance above the base of the pale beds.

Lower portion
of Belly River
series.

The separation of the lower, or yellowish and banded portion of the

*Geology and Resources of the 49th Parallel, p. 120.

†Ibid, p. 114.

Belly River series
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The Belly River
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calcareous shales.
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limited size appear
The fossils are mari-
bones from the west
In Rocky Spring

Belly River series, from that above referred to, is made merely for convenience of description and is probably not warranted in any other sense. The distinctive characters of the two portions of the series are indeed so indefinite that though little hesitation might be felt in relegating a given large exposure to one or other, the points of difference vanish when any attempt to draw a precise line is made. The yellowish and brownish colours of the lower beds are probably in connection with the fact of their brackish-water character, evidenced by abundant and well-preserved molluses; but in addition, this lower portion of the series is more evenly bedded and composed of more rapidly alternating layers. These consist of sandy clays, sandstones, and shales, which frequently blend so completely with each other as to render it very difficult to give definite measured sections. Those described on pages 44c and 76c may be taken as most characteristic. The top of this portion of the series appears to be defined on the Belly River by some rather massive yellowish sandstones, and this is probably also the case on the Bow. On the Milk River near Dead Horse Coulee, and in the escarpment of the Rocky Spring Plateau, massive grey and yellowish sandstones, irregularly hardened and often weathering into remarkable castellated forms, occur at its base. Besides the molluses above alluded to, dinosaurian, chelonian and other bones are found in some places in considerable abundance.

Of these yellowish beds about 350 feet was found on the Milk River ^{Thickness.} east of Pā-kow-kī Coulee, and this is probably the full thickness at this place, while 150 feet or more is shown on the Belly underlying the lignite-coal last alluded to. Lignite seams are also found well down in these beds, but so far as observed they are quite unimportant in character.

The Belly River series has not yet been definitely identified in any part of the disturbed belt bordering the mountains, where, from the complicated character of the sections and absence of fossils, it is difficult to discriminate between it and the lithologically similar beds of the Laramie.

The lower dark shales are clearly seen to underlie the yellowish por- ^{Lower dark shales.} tion of the Belly River series on Milk River at Pā-kow-kī Coulee. The main lithological difference which their upper portion shows, as compared with the Pierre, is the greater abundance of sandy and calcareous shales. The lower beds were not well seen, except in the country south of the Rocky Spring Plateau, where sections of limited size appear to show that they are soft and very dark shales. The fossils are marine, and with the exception of a few large reptilian bones from the west flank of the West Butte, all molluses.

In Rocky Spring Plateau a thickness of 235 feet of these beds was ^{Thickness.}

examined (p. 42c.) It is probable that their entire thickness is about 800 feet at the West Butte. It is almost certain that a number of the bands of dark shales met with in the disturbed belt belong to this series.

Conditions of
deposit implied
by rock-series.

We thus find that the oldest Cretaceous beds so far defined in this district are marine, that the marine are succeeded by brackish-water conditions, in the lower part of the Belly River series, while a fresh-water lake followed in the period represented by the upper portion. Renewed subsidence brought the sea once more over the region, and the Pierre shales were laid down, but toward the close of this period the waters became shoal, limited areas supported a brackish-water fauna, and as this was gradually extinguished the great fresh-water Laramie lake covered the region and continued to prevail to the close of this record. The whole district was probably one of gradual or intermittent subsidence throughout Cretaceous and Laramie time, and there is reason to believe that the amount of subsidence and thickness of sediments was greatest in the vicinity of the present position of the eastern ranges of the mountains. The Cretaceous and Laramie beds spread far into the mountain region, where they now occur in isolated troughs and basins, and it is evident that the greater portion of the existing Rocky Mountain range was upheaved at a date long subsequent to the latest of the beds here described. It is also shown, however, that land, possibly in the form of an archipelago, existed in this vicinity, and that rocks similar to those of the mountains of to-day and hardened to a like extent, were there undergoing denudation, and supplied the material not only for the conglomerates above alluded to, but also for the finer beds now underlying the area of the plains. It must further be conceded that tracts of low land appeared above the surface at a number of epochs, and indeed that at several stages the region was preponderatingly one of swamp and morass in which the vegetation which has produced the coals and lignites grew and accumulated.

Comparison
with Peace
River section.

The general sequence of events is precisely similar to that proved to have taken place much further north in the region of the Peace River, with the rock series of which the present section may instructively be compared.*

STRATIGRAPHICAL POSITION OF THE BEDS OF THE BELLY RIVER SERIES.

General bear-
ings of the
question.

As the general section of the rocks of the region embraced by this report differs so considerably from that usually taken as typical in the contiguous Upper Missouri region, it seems necessary to review the main points in evidence which have led to its adoption. These points have been carefully considered in all their bearings, and have also

*Report of Progress Geol. Surv. Can., 1879-80

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been made the subject of investigation. It has not been till recently that it has been proved untenable. It was first expressed in 1875, in the Geology of the Northwest Territory, in the scheme here given by Messrs. Meek and myself, in the Cretaceous sub-

The views now prevailing are nearly with those of the previous which—judging from the sections on the 49th

Briefly stated, it is not that consideration of the "Tertiary"—the Belly River series, shales, or at least the beds thus separated, related with the Jurassic extensive collection, out, confirm and the assumption that the position well down that this was the view and supported, it was the vertebrate remains stratigraphical evidences impressions resulting from the make of the Mississippian ascending the river the sequence of the these into exact position Peace River, near the

While allowing the investigation, it may be in the region now underling these rocks as present a synopsis of

* Geology and Resources of Canada. Section IV., p. 156.
† Op. cit. p. 156.
§ Proc. Acad. Nat. Sci. Phila.

been made the subject of additional special investigations in the field. It has not been till, as I conceive, every reasonable alternative has been proved untenable that I have been obliged to change the opinions expressed in 1875 in regard to a considerable part of the beds reported on in the *Geology and Resources of the 49th Parallel*, and to adopt the scheme here given, which appears also to involve some modification of Messrs. Meek and Hayden's later views on the order of succession of the Cretaceous subdivisions.

The views now held, however, it may be mentioned agree more nearly with those entertained by Dr. Hector, in his final reports, which—judging from Missouri analogies and my own reading of the sections on the 49th parallel in 1874—I was inclined to doubt.*

Briefly stated, it would appear from the investigations now reported on† that considerable areas of the beds, which in 1874 I called “Tertiary”—here and in previous announcements designated as the Belly River series—must be relegated to a position below the Pierre shales, or at least to one below an upper portion of these shales. The beds thus separated as the Belly River series, were, in 1875, by me correlated with the Judith River series of the Missouri.‡ Additional and extensive collections of fossils since obtained, and now being worked out, confirm and strengthen this correlation, and lead to the presumption that the so-called Judith River series must also occupy a position well down in the undoubted Cretaceous. It may be added that this was the view originally held by Messrs. Meek and Hayden, and supported, it would appear, not alone on the supposed analogies of the vertebrate remains examined for them by Prof. Leidy, but also on stratigraphical evidence,§—evidence which perfectly agrees with the impressions resulting from such cursory examination as I was able to make of the Missouri sections from the deck of a steamer while ascending the river in 1881. It may further be interesting to note that the sequence of the Cretaceous subdivisions here maintained, brings these into exact parallelism with those previously studied on the Peace River, near the 56th parallel of north latitude.

While allowing that the question is one deserving still further investigation, it may be stated that a careful study of all the available facts in the region now under discussion, leaves me no option in representing these rocks as they appear on the map. It is proposed here to present a synopsis of these facts.

* *Geology and Resources of the 49th Parallel*, p. 158.

† See also Note on *Geology of the Bow and Belly River Region*, 1882, *Proc. Royal Society of Canada*. Section IV., p. 39. *Science* Vol. iii., p. 647.

‡ *Op. cit.* p. 156.

§ *Proc. Acad. Nat. Sci. Phil.*, Vol. viii., p. 114.

Wide undulations of the Cretaceous and Laramie.

Eastward from the edge of the disturbed belt of Cretaceous and Laramie rocks which immediately fringes the mountains, the general structural features of the district are very simple. We cross first a shallow synclinal, which widens much northward, and the axis of which is occupied for a considerable portion of its length by the Porcupine Hills. East of this, and occupying the whole eastern part of the map, is a still more diffuse anticlinal swell, the axis of which runs first a few degrees west of north, to the confluence of the Bow and Belly, then east of north to the edge of the district. The intrusive masses of the Sweet Grass Hills occupy the centre of this great anticlinal swell, where it crosses the 49th parallel; and around the northern flanks of these, and in the valley of Milk River opposite them, what appear to be the oldest rocks exposed in the district occur. These are dark shaly and sandy beds, elsewhere fully described, which though holding a rather mixed fauna, still show several forms usually considered as distinctively belonging to the horizon of the Pierre, and render it probable that these beds do not represent the typical Benton group, which their relations would otherwise appear to favour. These beds undoubtedly underlie the Belly River series, as is clearly shown on the Milk River, at the mouth of Pa-kow-ki Coulee. They re-appear in the south-eastern escarpment of the Rocky Spring Plateau immediately south of the 49th parallel. (See p. 42 c.)

Relations of series near east edge of map.

Along the eastern side of the broad anticlinal above defined, the relation of the Belly River series to the typical Pierre shales is very clear. Lying above the lower dark shales, at the point on Milk River just alluded to, it is continuously exposed in the valley of the river to the eastward to its crossing of the 49th parallel. The yellowish, or lower part of the Belly River series at first occupies the banks to the prairie level, but in consequence of a light eastward dip, which—as estimated in a distance of seven miles near the 49th parallel—amounts to at least thirteen feet to the mile, the whitish, or pale coloured upper portion of the series soon appears, forming a somewhat higher plateau on both sides of the river; and before the valley ultimately crosses the Boundary line, seems to occupy the entire height of the river-banks, with a thickness of at least 300 feet. The north-eastern edge of the higher plateau above noted, is found near the Lac des Marrons, beyond the edge of the present map, and in this region (which is at present being mapped by Mr. McConnell), similar light easterly dips have been found to prevail, though the angle is probably somewhat greater than on the Milk River. As a result of this dip the Pierre shales are soon found to occupy the whole surface of the country, notwithstanding the fact that the level of the prairie to the eastward is lower than that of the above-mentioned plateau. On Sage Creek, north of the Lac des Marrons, Mr. McConnell has actually

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observed the super beds of the Belly

As above stated westward and some one hundred and nearly in the east just described appear to quote Messrs. M authors write:—“ which are not seen again rise to view series (No. 5 and to the east, are found that nearly all the shell rivers, consisting the mouth of the Milk above the water level No. 3,† not being increasing inclination in the vicinity of Missouri. Here, as the *Mauvoises* T in these Bad Lands with beds of clay distorted. It was found formations time and Tertiary strata off from the party fossils collected, it to think with Prof. taceous system, a however, as there in these Bad Lands remains may belong distinct species fossils localities in this region.

It may be worth above stated, but that on the line of the referred to. I am

* Fox Hill and Pierre.
† Dakota, Benton and M
‡ Proc. Acad. Nat. Sci.

observed the superposition of the Pierre on the upper or pale-coloured beds of the Belly River series.

As above stated, the axis of the wide anticlinal runs in a north-westward and south-eastward course near the 49th parallel, and about one hundred and seventy miles distant, at the mouth of the Milk River, nearly in the continuation of the same bearing, the arrangement just described appeared to be exactly repeated. It may be well to quote Messrs. Meek and Hayden's observations on this point. These authors write:—"Near the mouth of the Milk River, Cretaceous strata which are not seen for a long distance below this on the Missouri, again rise to view. They consist of the upper two members of the series (No. 5 and No. 4),* which, in consequence of their inclination to the east, are found to rise higher and higher as we ascend the river, so that nearly all the hills close to the Missouri, between Milk and Mussel-shell rivers, consist of these formations. Some four or five miles below the mouth of the Musselshell River, a lower rock,—a sandstone,—rises above the water level. This is probably No. 1 of the series, No. 2 and No. 3,† not being represented here." * * * "In consequence of the increasing inclination of the strata, this last-mentioned sandstone rises in the vicinity of North Mountain River as much as 250 feet above the Missouri. Here, or near this, begins a wild and desolate region known as the *Mauvais Terres* or Bad Lands of the Judith. At various places in these Bad Lands a sandstone similar to No. 1 was seen alternating with beds of clay and lignite, all of which are upheaved and much distorted. It was found impossible to devote to the examination of these formations time enough to determine their relations to the Cretaceous and Tertiary strata of this region, without running the risk of being cut off from the party and murdered by the Indians." After a notice of the fossils collected, it is added: "From these facts, we are strongly inclined to think with Prof. Leidy, there may be here, at the base of the Cretaceous system, a fresh-water formation like the Wealden. Inasmuch, however, as there certainly are, some outliers of fresh-water Tertiary in these Bad Lands, we would suggest that it is barely possible these remains may belong to that epoch, though the shells appear to be all distinct species from those found in the Tertiary at all the other localities in this region."‡

It may be worthy of note, that not only the Sweet Grass Hills, as above stated, but the Bear's Paw and Little Rocky Mountains lie nearly on the line of the southern portion of the anticlinal swell previously referred to. I am unacquainted with the geological structure of the two

Similar
sequence of
beds on the
Missouri.

Line of intru-
sions along
anticlinal.

* Fox Hill and Pierre.

† Dakota, Benton and Niobrara.

‡ Proc. Acad. Nat. Sci. Phil., Vol. viii., p. 114.

last named groups of mountains, but think it probable that it resembles that of the Sweet Grass Hills, while the disturbed region, above described by Messrs. Meek and Hayden, nearly forms a continuation of the same line, and the disturbances, which are of a local character, are connected with the appearance of igneous dykes and protrusions.

Base of Pierre
shales proper.

As previously shown in detail in this report, one of the most constant features throughout the entire district is the occurrence of a coal-bearing or lignitiferous horizon at the base of the typical Pierre shales.*

Western edge
of Pierre area
beyond limit
of map.

This is found in its usual position in the sections on Sage Creek above alluded to, and serves to assist in the definitive correlation of the overlying shales with those above the coal at Coal Banks, Belly River. On Sage Creek a length of outcrop of two miles showed a south-eastward slope of the base of the Pierre at the rate of twenty-five feet to the mile, though this may not represent the direction of greatest inclination here. Beyond this place, the general trend of the western or lower edge of the Pierre shales is a few degrees west of north for about forty miles, to the low hills near the Bull's Head and north of Peigan Creek, the outcrop of its base nearly following a contour line at a height of 3,000 feet, but declining slightly to the north. East of Lake Pa-kow-ki the Pierre forms well marked plateaus, while the lower country between these and the lake, in the valley of Many Berries Creek and two streams north of it, shows fine sections of the upper or pale-coloured portion of the Belly River series. After a concealed interval, the base of the Pierre shales, with its usual carbonaceous character, is again seen in a tributary of Peigan Creek, south of the main stream. From the hills above characterized as near the Bull's Head, where the base of the Pierre shales is found distinctly overlying the pale beds, it appears to run north-eastward for about twenty-eight miles to Ross Creek,† near the line of the Canadian Pacific Railway, where its relation to the underlying beds and coaly base were again observed by Mr. McConnell. In this distance the level of the base decreases by at least three hundred feet, though the direction of dip is probably more nearly east than north-east.

Eastern out-
crop of upper
part Belly
River series.

With the exception of inconsiderable concealed areas, the upper portion of the Belly River series is traceable from the Bull's Head Hills north-westward to the South Saskatchewan near Medicine Hat, where it is again recognisable, and caps the lower or yellowish portion of the same series. North of the railway line, in this region, the drift covering is so deep that it is difficult definitely to trace the edge of the Pierre,

* This horizon I observed occupying the same position on the Missouri, where it is also described by Prof. Cope. Bulletin U. S. Geol. and Geog. Survey, Vol. VIII., p. 566.

† Near Irvine Station, sixteen miles east of Medicine Hat.

but on the Red D observed the Pier River series, the t and fifty feet. TH South Saskatchewan ever, owing to t perhaps some do carbonaceous beds

From the Medic beds have been fo the confluence of f continuously, or w are concealed, to t defined on the m merely light local original irregulari vious pages of this the Bow, the disti and passing into t

On the western Belly, the superp Belly River series mouth of the St. M where examined b this junction is not ing the river is the

In the Milk River Benton trail the re are not so distinct study, it might ha lower portion of th lying the Pierre sh Hill synclinal and tional anticlinal sw found. This is m perhaps, be tracea below the mouth Mahan's Coulées, t the coal-bearing h much reduced in i Banks. The pale in several places Coulée, and a few

but on the Red Deer River, north of Rainy Hills, Mr. McConnell has observed the Pierre shales overlying the pale upper beds of the Belly River series, the thickness of the shales seen being about one hundred and fifty feet. The same circumstance is also reported by him on the South Saskatchewan, thirty miles north of Medicine Hat, where, however, owing to the small thickness of the overlying shales, there is perhaps some doubt as to their identity. In both localities, however, carbonaceous beds occur near the base of the shales.

From the Medicine Hat exposures of the Belly River series, these beds have been followed westward along the South Saskatchewan to the confluence of the Bow and Belly, and thence up both these rivers, continuously, or with but small and unimportant gaps where the beds are concealed, to the western line of outcrops of the Pierre shales, as defined on the map. The beds are throughout horizontal, or show merely light local undulations, scarcely greater than may be due to original irregularity in deposition. At two points, described on previous pages of this report, one on the South Saskatchewan and one on the Bow, the distinctively pale upper part of the series is seen overlying and passing into the lower yellowish and banded beds.

On the western side of the wide anticlinal, below Coal Banks on the Belly, the superposition of the Pierre shales on the pale beds of the Belly River series is perfectly clear, and is again well shown at the mouth of the St. Mary River. The same may be said of the Red Deer, where examined by Mr. McConnell. On the intervening Bow River this junction is not actually seen, but the general sequence in descending the river is the same. These sections are elsewhere fully described.

In the Milk River Ridge a. 1 on the Milk River west of the MacLeod-Benton trail the relations of the Pierre shales to the Belly River series are not so distinct, and had this been the only district available for study, it might have been assumed that the yellowish, and as I believe, lower portion of the Belly River series, formed an upper set of beds overlying the Pierre shales. Between the southern end of the Porcupine Hill synclinal and the great low anticlinal previously defined, an additional anticlinal swell of the slight kind characteristic in this region, is found. This is most pronounced at the Milk River Ridge, but may, perhaps, be traceable northward in a much reduced form to the Belly below the mouth of the St. Mary River. South of Middle and Ed. Mahan's Coulees, the Milk River Ridge is capped by the Pierre shales, the coal-bearing horizon being displayed in a number of places, but much reduced in importance as compared with its development at Coal Banks. The pale upper portion of the Belly River series is well shown in several places below it, particularly at the locality named Fossil Coulee, and a few miles east of this point an oyster bed, identical with

Transverse
sections of
area of Belly
River series.

Relations of
series near
Coal Banks.

Relations of
series in Milk
River Ridge
and on Milk
River.

occupying a similar position at the mouth of the St. Mary, is associated with thin coal-seams. From Fossil Couleé to a point on the Milk River, twelve miles south-eastward, the base of the Pierre dips at the rate of nearly sixty feet to the mile, and it is not known whether this is the direction of greatest slope. After a concealed interval of about a mile and a half on the river, yellowish sandstone and sandy clays appear, and so far as the rather limited sections show, run down the Milk River for many miles, nearly following its eastward slope.

Rocks on
Verdigris
Coulée.

Along Verdigris Coulée to the north-east, are good sections of beds which, from their lithological character might represent either the pale or yellowish portion of the Belly River series. The appearance is at first sight quite in favor of the belief that all these overlie the Pierre shales. On working out, however, the barometric elevations for this part of the country, it is found that to the north-east of the ridge, the general level of the surface descends about as rapidly as the slope above determined for the Pierre, for a part of the distance, and I believe that probably in consequence of a light westward dip affecting the beds of the region east of the McLeod-Benton trail, combined with the general descent of the level of the prairie, the Pierre shales run out eastward, and the beds above referred to on Verdigris Coulée occupy in reality an inferior position, as the previously detailed observations appear to prove elsewhere.

Thickness of
Belly River
series on Milk
River.

On the hypothesis thus accepted, however, it is evident that the whole thickness of the Belly River series must outcrop along the Milk River between the Pierre shale exposures in the vicinity of the Mac-Leod-Benton trail-crossing and the appearance of the lower dark shales on the river north of the Middle Butte,—a distance of about thirty miles. As a matter of fact this distance is still further reduced to that between the McLeod-Benton trail and mouth of Verdigris Coulée—about twenty miles—by the circumstance that the castellated or pillared sandstones, the top of which sinks below the river level near the mouth of Verdigris Coulée, have been traced at a varying height along the sides of the main valley to the mouth of Dead Horse Coulée, and through this coulée, in a modified but perfectly recognizable form to its east end, where they closely approach, but were not observed in contact with the supposed lower zone of dark shales. Disregarding light minor undulations, these sandstones may be considered as indicating the proximate horizontality of the beds, for, in a short distance of three miles below Verdigris Coulée, they rise eastward at the rate of about twenty-three feet to the mile in the bank, a rise which is nearly accounted for by the slope of the river-valley itself, but perhaps favors the belief in a very light westerly dip in addition. From observations detailed elsewhere, there is little doubt that these sandstones immediately overlie the lower dark shales.

On the supposition of the elevation of the Pierre near the McLeod-Benton trail, the maximum thickness of the Pierre is less than the thickness of the Belly River series, and may be expected, in connection, however, with the Milk River—these facts concerning the Milk River Ridge may be compared with the thickness of the Belly River series as compared with the Pierre shales, which may be referred to nothing,—is places along the angles to the trend of the barrier such as shown explain.

Before leaving the Pierre shales of the series Spring Plateau, of the Middle Butte, their agreement with the Pierre north of the Middle Butte, on the hypothesis of the lower subdivision, show only the upper part, viz., that the whole of the Pierre is this correlation and the Coal Banks series in any case, be prepared to accept of the alternative scheme of the Pierre shales and banded shales holding Judith River implies their uncertainty, no possible doubt

On the supposition of the horizontality of the beds, the increased elevation of the country westward to the Pierre shale outcrop near the McLeod-Benton trail-crossing allows a thickness of about four hundred and sixty feet of beds to be accounted for, adding to which the maximum observed thickness of the sandstones themselves, a total maximum thickness of about 530 feet might be allowed for the entire thickness of the Belly River series in this region. This is somewhat less than the thickness of the series as elsewhere developed would lead us to expect, and may by closer examination be still further reduced. In this connection, however, it is interesting to note that the Pierre shales on the Milk River—though their precise volume has not been determined—are evidently much thinner than on the Belly at Coal Banks, and further, that the sections on the Milk River, near the west end of the ridge, show that the lower, or St. Mary River sub-division of the Laramie, as compared with the section to the north, on the St. Mary, is quite thin also. These facts concur in indicating that the region now occupied by Milk River Ridge may have been an area of small deposition throughout later Cretaceous and Laramie time, probably owing to its greater elevation as compared with the rest of the sea-bottom. A further circumstance which may be referred to as favouring this view,—though in itself proving nothing,—is the existence of ripple-marked sandstones in several places along the St. Mary, to the north, indicating currents at right angles to the trend of the base of the mountains, which, if no transverse barrier such as shoal water or land existed in this vicinity, it is difficult to explain.

Cretaceous and Laramie thin near Milk River Ridge.

Probable shoal near present position of the Ridge.

Before leaving this region, it may be well to note that while the dark shales of the series exposed in the south-eastern escarpment of the Rocky Spring Plateau, closely resemble those seen on the flanks of the West Butte, their agreement is not so satisfactory with those of the Milk River, north of the Middle Butte and at the mouth of Pā-kow-kī Coulée, while on the hypothesis adopted, all these localities must represent a single lower subdivision. The Milk River sections just referred to, however, show only the upper part of the series, while the alternative hypothesis, viz., that the whole belong to the Pierre shales proper, also necessitates this correlation and besides involves their identity with the Milk River and Coal Banks shales, which are still more dissimilar. We must, in any case, be prepared to allow considerable local diversity in this area.

Diversity in character of shales.

Taking the whole district into consideration, the only reasonable alternative scheme of arrangement of the beds by which the yellowish and banded series here included in the Belly River series and holding Judith River fossils can be assigned a position above the Pierre, implies their unconformity on the Cretaceous proper. There can be no possible doubt as to the position below the Pierre shales of the pale

Other possible hypotheses as to position of Belly River series.

beds which are here classified as the upper portion of the Belly River series. It might be *assumed* that the yellowish and banded beds overlie these unconformably, but we must then also admit that on the Bow and Saskatchewan rivers these are capped by a *second* pale series, lithologically precisely the same with that above referred to. Further, we must suppose that a great basin had been produced in the Cretaceous by denudation, and that this was so formed that around its whole margin, both on the east and west sides, its shore-line consisted of the pale beds known to underlie the Pierre shales proper. However improbable such a co-ordination, it appeared to afford a possible alternative. During the past season, however, it has been found that in a number of places, the pale beds actually seen beneath the Pierre shales, hold molluscs identical with some of those in the yellowish beds, and with those of the so-called Judith River formation. One of the most characteristic and abundant is *Corbula perundata*. Even the adoption of the improbable hypothesis above outlined, therefore, does not free us from the necessity of allowing the existence of a Judith River fauna below the typical Pierre shales, and it was this very circumstance which led to the endeavour to explain the section on the supposition of the superior position of the yellowish beds, and the wish to establish a line of distinction between these and the pale beds, with which all the observed facts seem to show that they are inseparably connected.

Palaeontological evidence.

Without entering at length into the palaeontological evidence, which is at present being investigated by Mr. Whiteaves, it may be proper to state, in further confirmation of the section here adopted, that where beds known to represent the brackish-water base of the Laramie occur, at Rye-grass flat on the Old Man River, at Scabby Butte, and on the Bow a few miles above Blackfoot Crossing, the general facies of the fauna differs considerably from that of the Belly River series. This is particularly shown by the constant presence in these beds of a large *Corbula* resembling *C. pyriformis*, but specifically new, which has not been found in the Belly River series; also by the entire absence from these beds of *Corbula perundata*,* one of the most abundant and characteristic forms of the Belly River series, and this though the conditions under which both sets of beds have been deposited, must have been practically identical.

Evidence afforded by fuels.

The position which the fuels contained in the rocks of the Belly River series, are found to occupy with respect to composition appears to afford additional conformatory evidence of the position assigned to them, from an unexpected quarter. (See p. 136 c).

* A single exception to this statement may possibly be found in the case of a shell much resembling *C. perundata*, which occurs in the loose fragment referred to on p. 37 c, as being probably of Laramie age.

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USEFUL MINERALS.

COALS AND LIGNITES.

In the area included in the present report nothing is more remarkable than the universal distribution and vast aggregate quantity of fuels available for economic purposes. The Belly River series, the Pierre and the Laramie formations all contain fuels of a workable character, and it may be stated without exaggeration, that practically the whole of the area which in a preceding chapter is designated as "the plains," is, so far as can be ascertained from the natural exposures, continuously underlain by coals or lignites, while considerable tracts are underlain by two or three successive fuel-bearing horizons. Within the area of the accompanying map there is, in fact (with the exception of a small district in the north-east corner which may yet be found to lie near outcrops in the adjoining areas to the north or east) no point more remote than thirty miles from some natural coal or lignite outcrop suitable at least for local use, while the natural exposures in several localities serve to prove the existence of available and easily accessible fuel for centuries of consumption on the most liberal scale.

The data available from the natural outcrops are insufficient to enable any general estimate of the quantity of mineral fuel existing in the entire region, but of this some idea of an approximately correct character may be formed for certain limited districts, and this is amply sufficient to show that the supply is practically inexhaustible. The horizon at the base of the Pierre is the most persistently coal-bearing so far proved in this region, and has been found to carry seams of varying thickness and quality wherever good sections of it occur. The outcrop of these fuels which occurs on the Belly River, near Coal Banks, has been traced southward at intervals nearly to the 49th parallel, and north-eastward to the Red Deer, a total distance of about one hundred and fifty miles. The southern and south-eastern extremities of this outcrop can not, owing to the thin character of the seams, be ranked as workable, but on the Belly and lower part of the St. Mary a length of outcrop of fully eighteen miles may be considered—from the existence of numerous good sections—as workable throughout, and in the immediate neighbourhood of Coal Banks, as stated in the preliminary report, is estimated to hold 5,500,000 tons of coal per square mile. Assuming—an assumption probably far below the mark—that this fuel may be worked with the greatest facility for a width of a mile, the length of eighteen miles of outcrop above defined would alone contain 99,000,000 tons. It is the same coal-bearing zone which occurs at a

(great abundance of coals and lignites.

Estimates of quantity of fuel.

Coal-seams at base of Pierre.

distance from the St. Mary River sections of sixty-six miles, on the Bow River at Grassy Island, where a quantity of 5,000,000 tons has been estimated as underlying each square mile. This may be assumed as a probable minimum for the portion of the outcrop above stated. That it continues at this or a greater thickness along the entire intervening length can be actually determined only by a system of borings, but if it falls below this figure in some places, this is probably more than compensated by the increased thickness in others, and by the fact that it may be worked—in consequence of its nearly horizontal attitude—much further from the outcrop than one mile. Taking the above minimum figure, however—merely for the purpose of forming a rough estimate of the capabilities of this seam—it is found that the resulting quantity for one mile in width along the line of outcrop is 330,000,000 tons, or, allowing for waste, equivalent to an output of about 1,000,000 tons for a period of 300 years.

Medicine Hat
seam.

The thickest seam found underlying the county in the vicinity of the Medicine Hat mines, may also be stated, on the average, to equal about 5,000,000 tons to the square mile, and the sections in the river banks may safely be assumed to prove its existence for an area of thirty square miles, the workable coal underlying which would, therefore, be about 150,000,000 tons. The seam near Horse-shoe Bend, on the Bow, has been estimated to equal about 4,900,000 tons per square mile. As this seam has, however, only been seen at a few places in this one locality, and is probably of a local character, it would scarcely be safe to assume that it underlies more than ten square miles, giving a total of 49,000,000 tons. The river exposures in the neighbourhood of the Blackfoot Crossing, together with the borings lately carried out by the Canadian Pacific Railway Company and the general persistence over the entire region of a seam at about this stage in the Laramie, appear to render it safe to state the proven area in this vicinity at about thirty square miles, which, as this seam is a thick one, should hold coal to the amount of 9,000,000 tons per square mile, or a total of 270,000,000 tons.

Practically
inexhaustible
character.

By computing the amount of fuel for a small area in connection with the outcrops on the Red Deer, and in the numerous localities in the foot-hills and mountains at which good seams occur, the figures above given for a few districts might be vastly increased, but the practically inexhaustible character of the deposits once conceded these would possess little additional meaning. While over the area of the plains the nearly horizontal attitude of the beds and the persistent cover of drift deposits prevents the foot-by-foot tracing of the seams, they may be very readily proved wherever desired by boring, and may

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be cheaply and more thoroughly localities will doubt a number of lines of a very minute even the natural angles up to vertical positions in extent, the quality, the fuels from the lignite-coal apply to the very forming basins or tains.

Touching the general details will be found where also remarkable and utilization are it is unnecessary to forming a part of desirable to add, however, foot-hills rank no volcanic formation of New classed as true li producing power, and employed successfully steam-raising and burning bricks, which of construction is lowest class may be The value of the with the mining, so likely there to be of kind some even of tually be utilized.

The annexed list of outcrops of coal have to the descriptive po

be cheaply and conveniently mined. As the foot-hill region becomes more thoroughly known and thickly settled, numerous additional coal localities will doubtless be found, for the seams are there repeated along a number of lines by the parallel folding of the beds, and nothing short of a very minute examination will serve to exhaust the possibilities of even the natural exposures. The seams are, in this belt, found at all angles up to verticality, and though thus likely to cause greater complications in extraction, this is compensated for by their superior quality, the fuels of this district being all true coals, as distinguished from the lignite-coals and lignites of the plains. The same remarks apply to the very interesting areas of Cretaceous and Laramie rocks forming basins or troughs between the Palæozoic ranges of the mountains.

Touching the quality of the coals and lignites, full and precise details will be found in the accompanying report by Mr. C. Hoffmann, where also remarks and experiments bearing on their practical value and utilization are given. Further statements under this head, which it is unnecessary to repeat, are published in my preliminary report, forming a part of the Report of Progress for 1880-82. It may be desirable to add, however, that some of the coals of the mountains and foot-hills rank no whit behind those of the Carboniferous or coal-bearing formation of Nova Scotia and the Eastern States, while even those classed as true lignites are greatly superior to wood in heat-producing power, and may, with suitable conditions of combustion, be employed successfully not only for ordinary domestic heating, but for steam-raising and in manufacturing purposes generally. For use in burning bricks, which on account of the scarcity of wood for purposes of construction is an important consideration, lignites of even the lowest class may be employed.

The value of the coals of the mountains and foot-hills in connection with the mining, smelting, and reduction of the metalliferous deposits likely there to be developed, is very obvious; and for purposes of this kind some even of the more remote and inaccessible seams may eventually be utilized.

The annexed list enumerates the principal localities where natural outcrops of coal have been found, and serves, in this regard, as a key to the descriptive portion of the report:—

List of the principal localities in which natural outcrops of coal and lignite are known to occur, within the area covered by the present report and map.

	LOCALITY.	Thickness of Seam.	Page of report in which locality is described.
1	Milk River 1 mile west of MacLeod-Benton trail-crossing	3 to 4 seams of about 6 inches	39 c.
2	Milk River Ridge; north slope at head waters of Middle and Ed. Mahan's Coulees	1 ft. 6 in.	50 c.
3	Three miles north of Milk River, opposite Dead Horse Coulee	3 ft. 6 in.	43 c.
4	Coulée 3 miles south of east end Lake Pa-kow-ki ...	1 ft.	
5	Forty-mile Coulee, near Cypress trail-crossing	1 ft. 2 in.	53 c.
6	St. Mary River, 2 miles north of 49th parallel	1 ft. 6 in.	54 c.
7	Upper Belly River, 16 miles north of 49th parallel ..	1 ft.	61 c.
8	St. Mary River, 9 miles above mouth (several seams, two separated by two inches shale)	2 ft.	59 c.
9	St. Mary River, 7 miles above mouth (several seams, thickest)	3 ft. 8 in.	60 c.
10	St. Mary River, at mouth	3 ft. 6 in.	69 c.
11	Coal Banks, Belly River (main seam)	5 ft. 4 in.	70 c.
12	Belly River, 6 miles below Coal Banks (main seam)	6 ft.	73 c.
13	Belly River, 9 miles below Coal Banks (main seam)	4 ft. 8 in.	73 c.
14	Belly River, near Woodpecker Island	3 ft. 3 in.	75 c.
15	Belly River, north-west angle of Drift-wood Bend. (The seam referred to in this and the note immediately foregoing is the same, and is seen in a number of places along this part of the river).	1 ft. 6 in.	75 c.
16	South Saskatchewan River in numerous exposures from near Medicine Hat to a point 24 miles west of that place	1 to 8 ft.	77 c.
17	Scabby Butte	1 ft. 3 in.	79 c.
18	Bow River, near mouth of Highwood	A few inches	83 c.
19	Bow River, 4 miles west of Blackfoot Crossing	1 ft.	85 c.
20	Bow River, 3 miles east of Blackfoot Crossing (several seams closely related, total coal)	8 ft. 11 in.	86 c.
21	Coulée 6 miles south-east of Blackfoot Crossing (two seams closely related)	4 ft. 6 in.	86 c.

List of the principal localities in which natural outcrops of coal and lignite are known to occur, within the area covered by the present report and map.

22	Bow River, 3 miles west of MacLeod-Benton trail-crossing	3 to 4 seams of about 6 inches	39 c.
23	Grassy Island, Bow River		
24	Bow River, south of mouth (several seams)		
25	Little Bow River, near mouth		
26	Red Deer River, near mouth		
27	Red Deer River, near mouth		
28	Red Deer River, near mouth (two seams)		
29	Red Deer River, near mouth		
30	Indian Farm Creek, near mouth		
31	One mile south of Indian Farm Creek		
32	Mill Creek, 4 miles south of Indian Farm Creek		
33	South Fork of Oldman River, near house		
34	South Fork of Oldman River, near Garnett's house		
35	Middle Fork of Oldman River, near Garnett's house		
36	North Fork of Oldman River, near Garnett's house		
37	Highwood River, near mouth		
38	Highwood River, near mouth		
39	Near Highwood River, near mouth		
40	Jumping Pound, near mouth (reported)		
41	Coal Creek, Bow River, near mouth		
42	South Branch, Bow River, near mouth		
43	Little South Branch, Bow River, near mouth		
44	Crow Nest Pass, Bow River, near mouth		
45	North-west Branch, Bow River, near mouth		
46	North-west Branch, Bow River, near mouth		
47	Hills between North-west Branch and Bow River, near mouth		

List of the principal localities in which natural outcrops, &c.—Continued.

LOCALITY.	Thickness of Seams.	Page of Report on which described.
22 Bow River, 3 miles south of Horse-shoe Bend	4 ft. 4 in.	89 c.
23 Grassy Island, Bow River (main seam).....	4 ft. 6 in.	90 c.
24 Bow River, south-east of Little Rolling Hills (thick- est seam)	1 ft. 6 in.	92 c.
25 Little Bow River, north of Black Spring Ridge	About 3 ft.	
26 Red Deer River, near mouth of Rosebud.....	4 to 7 ft.	94 c.
27 Red Deer River, 18 miles below mouth of Rosebud .	3 to 4 ft.	94 c.
28 Red Deer River, about 8 miles above Hunter's Hill (two seams)	2 ft. and 3 ft.	95 c.
29 Red Deer River, 13 miles above Hunter's Hill.....	1 ft. 3 in.	
30 Indian Farm Creek near Pincher Creek	2 feet or more	98 c.
31 One mile south of road-crossing of Pincher Creek...		98 c.
32 Mill Creek, 4 miles above the mill.....	9 ft.	99 c.
33 South Fork of Old Man, 3 miles west of Garnett's house	2 ft. 10 in.	99 c.
34 South Fork of Old Man, about five miles east of Garnett's house (reported)	1 ft. 6 in. (?)	100 c.
35 Middle Fork of Old Man River, 6 miles north of Garnett's house (two seams)	3 ft. & 3 ft. 6 in	101 c.
36 North Fork of Old Man River, 1½ mile from moun- tains.....	4 ft.	103 c.
37 Highwood River, Middle Branch ¾ miles above Forks	1 ft.	104 c.
38 Highwood River, 4 miles above Forks.....	1 ft. 6 in.	104 c.
39 Near Highwood River at east base of Mountains ...	2 ft.	106 c.
40 Jumping Pound River, a few miles above Bow (reported).....	Not known	81 c.
41 Coal Creek, Bow River	1 to 3 ft.	80 c.
<i>Within Mountain Area.</i>		
42 South Branch, Old Man, 3 miles above mouth of Little South Fork.....	9 ft. 9 in.	109 c.
43 Crow Nest Pass, 4 miles west of the Gap.....	2 ft. 10 in.	110 c.
44 North-west Branch of North Fork, 2½ miles above mouth	8 ft. or more.	110 c.
45 North-west Branch of North Fork below Fall	3 ft.	111 c.
46 Hills between North-west Branch of North Fork and sources of Highwood, near water-shed range....	Numerous thin seams	111 c.

Change in composition of fuels near the mountains.

A point previously alluded to and of much interest in connection with the coals and lignites of the district included in the present report—whether regarded from a theoretical or practical point of view—is the gradual change which these materials are found to undergo on approaching the mountains. Though the analysis available for the North-west at the time of the publication of my report on the Geology and Resources of the 49th Parallel were comparatively few in number, and represented fuels scattered widely over the whole territory; this examination enabled the following general statement to be made:—

"On reviewing the whole of the analysis of the fuels, and referring them to their localities on the map, it will appear that lignites which contain, when thoroughly air-dried, above twelve per cent. of water, occupy the eastern part of the area occupied by the Lignite Tertiary, while beyond about the 113th meridian, many, if not most, of the fuels met with, contain less than that amount of moisture, and pass by easy gradations in some instances to coals indistinguishable from those of the Carboniferous formation. These two regions are not, however, mutually exclusive, for west of the line above indicated, lignites of the former class are often found, and also, apparently, fuels representing all intermediate stages. The mixture of the two classes in the extreme west would suggest either the presence of two distinct coal-bearing formations, or two different horizons of the same series of rocks."*

The increase of our knowledge of the fuels of this region has served to confirm, in a general way, the proposition then first stated. It has since been several times referred to in discussing their character, and it has been possible to make it even more definite than at that time.

Data available in this district.

The series of very carefully conducted analysis made by Mr. Hoffmann, (p. 11 M, et seq.) of specimens specially collected by us as representative of the various seams, renders possible a more precise investigation of the nature and amount of change by which the fuels have been affected in relation to their proximity to the mountains. It is still, however, a subject on which much more information is desirable, and the following discussion is to be regarded rather in the light of a suggestion than otherwise, as the number of analysis for the present region might, in this regard, be advantageously increased by three- or four-fold.

Positions of the fuels.

We have in this region, on the west, the Rocky Mountains, consisting largely of Palaeozoic rocks, but including also several long troughs of Cretaceous and Laramie Rocks. The eastern Palaeozoic range is remarkably straight and even in outline, and constitutes the edge of the mountains proper. East of this is a belt averaging about fifteen miles in width, composed entirely of Cretaceous and Laramie rocks, folded

* Geology and Resources of the 49th Parallel, p. 180.

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parallel to the direction of the base of the mountains, frequently vertical or nearly so for miles in width and everywhere showing evidence of intense lateral pressure and disturbance. The eastern edge of this belt is again very definitely bounded, and the rocks subside almost at once to a condition of practical horizontality, and so continue over the entire area of the Great Plains.

In the now isolated Cretaceous and Laramie basins of the mountains, the included fuels are for the most part of the character of bituminous coals, but in one case—that of the Cascade and Bow Rivers basin—where pressure from the west has been such as to completely overturn the synclinal trough, the alteration has proceeded so far as to produce an anthracite. In the disturbed belt of the foot-hills the fuels are also all entitled to rank as coals, and the hygroscopic water in the fuels of the region may be stated, according to Mr. Hoffmann's analysis, to range from 1.63 to 6.12. The eastern edge of this belt—at a mean distance, as above stated, of fifteen miles from the mountains—may be said practically to coincide with a water-content of 5 per cent.* On arranging the remaining analyses in their relative order of distance from the edge of the disturbed belt, without reference to their stratigraphical positions, the percentage of hygroscopic water is found to increase in very regular proportion with that of the distance, while the amount of volatile combustible matter shows a similar increase. That of the specific gravity of the fuels is too much affected by the quantity of ash to form a basis of comparison.

With a view to arrive at the best standard of comparison, the united percentages of the water and volatile combustible matter have been compared in a similar way, and the subjoined table also shows the percentage of the former constituent calculated for the fuels without ash, which it was thought might be eliminated with advantage. The result, however, shows but little difference from that obtained by considering the water as a constituent of the fuel in its natural state—ash included.

*Of Mr. Hoffman's analysis Nos. 23, 24, 25 and 28, may be taken as almost exactly representing this edge of the disturbed belt. These, with a specimen from the continuation of the same line on the St. Mary River (Geology and Resources 49th Parallel), represent the margin of the disturbed belt for a length of 170 miles, and give an average water-content of 5.14 per cent.

Coals of
mountains and
foot-hills.

Percentage of
water decreases
uniformly
westward.

Fuels compared
by water-
content.

TABLE (1) showing per centage of Water, Volatile combustible matter, &c., of Fuels, arranged in order of distance from edge of Disturbed Belt. (From analyses by Mr. C. Hoffmann.)

LOCALITY.	Miles from edge of Disturbed Belt.	Hygroscopic Water p. c.	Hygroscopic Water p. c. relatively to Combustible Constituents of Fuel.	Hygroscopic Water and Volatile Combustible matter p. c.	Ash p. c.
1. Indian Farm. Pincher Creek.	0	5.38	5.92	32.57	9.09
2. St. Mary River.....	35	7.02	7.49	36.43	6.29
3. Milk River Ridge.....	38	9.84	13.82	38.50	18.83
4. Coal Banks. Belly R.....	42	6.50	7.03	38.09	7.55
5. Belly R., below Little Bow.....	64	9.18	9.85	39.84	6.85
6. Blackfoot Crossing, (mean of 4)	64	11.55	12.33	41.82	6.31
7. Horse-shoe Bend. Bow River.	74	11.13	12.26	47.65	9.19
8. Grassy I. Bow R.....	86	11.90	12.65	43.10	5.93
9. Red Deer R. (mean of 2).....	86	13.64	14.19	44.84	3.87
10. Red Deer R. (mean of 2).....	100	13.34	14.59	43.66	13.34
11. Red Deer R. Coal Banks seam.	100	12.62	13.80	44.70	8.58
12. Medicine Hat.....	128	17.70	18.41	46.33	3.84

It will be observed that with the exception of one specimen† the results are closely concordant with the rule above referred to, and by arranging them in the form of a diagram in which each of the vertical lines represents a distance of ten miles from the edge of the disturbed belt, while the horizontal indicate the percentage of water, this is made even more apparent, and the rate of increase is shown to be about one per cent. in ten miles, very nearly.

On a careful inspection of the figures, however, it is observed that while the relation of the fuels to the disturbed belt has preponderant influence, there is also a quite perceptible effect due to stratigraphical position, the lower and older containing relatively less water than the

Influence of stratigraphical position on water-content.

†This (No. 3) is from Milk River Ridge. The seam is very thin and earthy, and the results are quite anomalous, however treated. It is just possible that the specimen may have been wrongly assigned. It has been practically disregarded.

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higher. With a the analyses may three formations

TABLE (2) showing etc., of Fuels, at the edge of the

LOCALITY

1. Indian Farm.
6. Blackfoot Crossing
7. Horse-shoe Bend
9. Red Deer R. (mean of 2)
2. St. Mary R.....
3. Milk River Ridge
4. Coal Banks. Belly R.
8. Grassy I. Bow R.
11. Red Deer R. Coal Banks seam.
5. Belly R., below Little Bow
10. Red Deer R. (mean of 2)
12. Medicine Hat..

In the second diagram the lines represent

higher. With a view to eliminating as far as possible the latter factor, the analyses may be arranged in three series, corresponding with the three formations in which the fuels occur thus:—

TABLE (2) showing percentage of Water, Volatile combustible matter, etc., of Fuels, arranged according to age and in order of distance from the edge of the Disturbed Belt. (From analyses by Mr. C. Hoffmann.)

LOCALITY.	Miles from edge of Disturbed Belt.	Hygroscopic Water p. c.	Hygroscopic Water p. c. relatively to Combustible Constituents of Fuel.	Hygroscopic Water and Volatile Combustible matter p. c.	Ash p. c.
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Laramie.

1. Indian Farm. Pincher Creek.	0	5.38	5.92	32.57	9.09
6. Blackfoot Crossing (mean of 4).	64	11.55	12.33	41.82	6.31
7. Horse-shoe Bend. Bow River.	74	11.13	12.26	47.65	9.19
9. Red Deer R. (mean of 2)	86	13.64	14.19	44.84	3.87

Pierre.

2. St. Mary R.	35	7.02	7.49	36.43	6.29
3. Milk River Ridge.	38	9.84	13.82	38.50	18.83
4. Coal Banks. Belly R.	42	6.50	7.03	38.09	7.55
8. Grassy I. Bow R.	86	11.90	12.65	43.10	5.93
11. Red Deer R. Coal Banks seam.	100	12.62	13.80	44.70	8.58

Belly River Beds.

5. Belly R., below Little Bow. . . .	64	9.18	9.85	39.84	6.85
10. Red Deer R. (mean of 2)	100	13.34	14.59	43.66	13.34
12. Medicine Hat.	128	17.70	18.41	46.33	3.84

In the second diagram the stratigraphical arrangement is illustrated, the lines representing separately the rate of increase in water of the ^{Explanation of diagram.}

fuels of each of the three horizons above referred to. The unbroken line is drawn with reference to the points representing the Laramie fuels, and it is quite probable that all of these are near the base of the formation and practically on the same horizon. The points on the dotted line represents the seam at the base of the Pierre, with the exception of No. 7, which is a seam locally developed at the top of that series. The line of dashes is drawn with reference to the points indicating the fuels of the Belly River series, and these again are very probably on precisely the same stratigraphical plane. This diagram, therefore, brings out very clearly the difference due to stratigraphical position, and by applying our local knowledge of the thickness of the strata, it would appear that in this district it amounts to about two per cent. of water for 1,000 feet in thickness of strata, that being approximately the volume of the beds intervening between the Laramie and Pierre seams. This fact has further a bearing on the question of the age of the Belly River series discussed in a preceding portion of this report (p. 118 c et seq.) as if this series really held a position above the Pierre, the fuels derived from it should in the diagram occupy positions in the upper line, rather than on a level with or rather below those of the Pierre. These fuels, from their comparatively large water-content might, at first sight, seem to compare more closely with those of the Laramie, but when the difference due to their greater geographical distance from the disturbed belt is allowed for, they fall naturally into the place assigned to them in the table of formations.

Bearing of composition of fuels on question of age.

Definition of limit of Laramie fuels containing 10 per cent. water.

Mr. Hoffmann, in the introductory portion of his report, alludes to the possibility of defining three zones parallel to the base of the mountains, the fuels in which correspond generally to the divisions adopted by him in classifying them in relation to composition. By marking on the geological map the positions of the various fuels represented by analyses, with the percentage of water in each, and measuring from these towards or from the edge of the disturbed belt, in lines drawn at right angles to it, on the basis above determined of a mean difference of one per cent. in ten miles; a theoretical line can be drawn separating the fuels which contain less from those which contain more than ten per cent. of hygroscopic water. In endeavoring, however, actually to define this line, it is found that it shows a marked eastward trend in the vicinity of the Belly River, whereas the edge of the disturbed belt here actually retreats in the opposite direction. This, however, evidently depends on the fact that the coals here used as standards belong entirely to the Pierre zone, and by applying a correction of two per cent. to these (equal to twenty miles in distance) the line falls back at this point and assumes an almost perfect parallelism throughout to that of the edge of the disturbed belt. The line thus arrived at for

Percentage of hygroscopic water relatively to combustible constituents of fuel.

Percentage of hygroscopic water relatively to combustible constituents of fuel.

DIAG

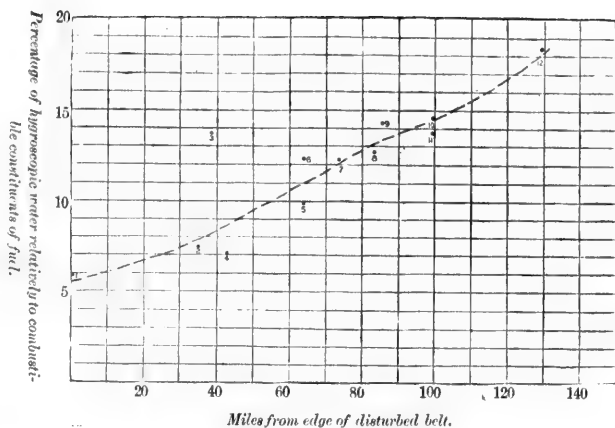


DIAGRAM I.

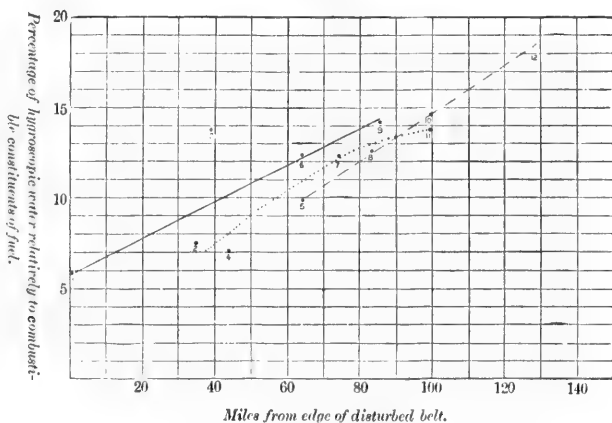


DIAGRAM II.

DIAGRAMS ILLUSTRATING RATE IN DECREASE OF HYGROSCOPIC WATER
IN LIGNITES AND COALS ON APPROACHING THE MOUNTAINS.

the Laramie, on the Blackfoot Crage distance of 1 belt.

Touching the observed in the flexure. If the flexure an becoming *gradual* found to change change was directed sharply-defined practically horizontal becomes evident due to the combination worthy of consideration thickness of superimposed, (m). The disturbed belt may be caused in the following manner: $(a + p) + (m + p)$

Assuming, as before, from the approximate difference in water level to admit a thickness of 100 feet at the edge of the disturbed belt, the 10 per cent. since been removed. In this hypothesis we may assume and if that be sufficient, given must be increased to require to be nearly 100 feet.

We have therefore of overlying beds of the mountains, the fact that some other cause can scarcely have effected the change. A part of the mountains and ranges must have been of the beds. It is in this way could have been able to believe that at least one hundred

the Laramie, or upper fuels, crosses the Bow about ten miles west of the Blackfoot Crossing, the Belly near Coal Banks, and is at an average distance of fifty-three miles from the eastern edge of the disturbed belt.

Touching the causes which have produced the remarkable change observed in the fuels of the plains, as they approach the disturbed belt:—

Possible causes
of change in
composition.

If the flexure and disturbance of the beds obtained over the entire area, becoming *gradually* reduced eastward, and the contained fuels were found to change in character *pari passu*, it might be supposed that the change was directly due to the disturbance. East of the edge of the sharply-defined disturbed belt, however, as before stated, the beds are practically horizontal. On an inspection of the second diagram it becomes evident that the actual amount of change in the fuels must be due to the combination of two or more causes. Three factors only seem worthy of consideration,—age, (*a*), pressure as represented by the thickness of superincumbent beds, (*p*), metamorphism by heat or otherwise, (*m*). The increasing change which occurs in approaching the disturbed belt may therefore have resulted from one or more of these causes in the following probable combinations. $a. + m$; $(a + p) + m$; $(a + p) + (m + p)$; $(a + p) + p$; or $p + p$.

Assuming, as by the last hypothesis, pressure to be the only factor; from the approximate measurement before arrived at—2 per cent. difference in water for 1000 feet of strata—it would be necessary to admit a thickness of superincumbent beds 2,500 feet greater at the edge of the disturbed belt (5 per cent. line) as compared with that of the 10 per cent. line, and to assume that this thickness of beds has since been removed by denudation. By the fourth of the above hypothesis we must attribute a portion of the loss of water to age, and if that be supposed to equal half the total effect, the figures last given must be increased to 5,000 feet. Both these figures would also require to be nearly doubled for the disturbed belt itself.

We have therefore to suppose either that a great additional thickness of overlying beds existed in a belt of uniform width along the base of the mountains, the strata gradually thinning eastward from this belt, or that some other agent, which may be denoted as metamorphism, and can scarcely have been other than heat, operated or assisted in producing the change. As igneous intrusions are practically absent from this part of the mountains it would appear that any heat emanating from the ranges must have been that produced by the crumpling and compression of the beds. It is difficult, however, to conceive that heat produced in this way could have had other than a local influence, and almost impossible to believe that it could have affected horizontal beds to a distance of at least one hundred miles.

Direct
influence from
mountains
improbable.

Probable
conditions of
change.

With reference to the first of the above hypotheses we have previously found reason to believe that a shore-line existed near the present position of the mountains, and it is quite probable that the strata are thicker in this part of the region and that overlying beds—like those of the Porcupine Hill series—may have been developed here only and subsequently removed by denudation. In the disturbed belt itself a heaping up of beds to almost any required amount may probably have occurred at the time at which the folding occurred. The burial of the fuels for a prolonged period under a great depth of strata implies not only greater pressure, but their subjection to the influence of the proper heat of the earth, and these two causes may probably be assumed as sufficient to account for the facts without resource—except locally—to the influence of the heat developed during the plication of the beds of the disturbed belt.

IRONSTONE, LIMESTONE, ETC.

Clay-ironstone. Clay-ironstones, of varying quality, occur in a great number of localities in association with the Cretaceous and Laramie rocks of this district, and in some cases in proximity to the coals. In a few places this material has been found in considerable quantity, notably on that part of the Bow River described on p. 91 c, and on the Kananaskis near its mouth. The manufacture of iron in this district—unless some very rich class of ore should be found in the mountains or foot-hills in large quantity—must, however, in the present state of the iron trade, be considered as a possibility of the remote future only. (See Appendix III.)

Cement stone. Calcareous and argillaceous concretions and nodular layers, likely to prove useful in the manufacture of hydraulic cements, are abundant. None of these have so far been put to any practical test, but they are likely to be in demand soon.

**Brick and
pottery.**

Some of the boulder-clays, and the silty deposits in some places overlying them, may doubtless prove applicable to the manufacture of ordinary bricks, but in the clays, soft argillites and fine silty materials of the underlying Cretaceous and Laramie series, materials suitable for the production of bricks of a very high class exist in the greatest abundance.

Some of these are true fire-clays, and would be available for the manufacture of the heavier and rougher grades of pottery, and for tiles and drain-pipes.

Building stone. Stone suitable for building purposes is by no means so universally found, and considerable care should be used in selecting Cretaceous or Laramie sandstones for masonry, as those of the plains are often but feebly coherent, with a scanty calcareous cement, and likely to disintegrate rapidly under the influence of the weather. In the foot-hills, however, many sandstones of excellent quality occur, and may be locally

[DANBON.]

employed, while the mountains t abundant.

Limestone can except in the fo glacial period, and The massive lime of supply of lime working where th places on the line that station. Th the map, may be the exception of Waterton Lake, i of Cambrian age

The occurrence to exist in remun in connection wit

SUPER

The superficial ently on the wor actual surface of those of the glacia the history of tha are deeply mantle neighbourhood of river-valleys. Th modified the appe character to, and soil.

The general cha are, however, so s detail into the d features, indeed, extraordinary per areas. Compared isimal, yet they ev continuity for hur As a part of the a whole, in connec

employed, while the railway affords a means of bringing down from the mountains the limestones and other hard Palaeozoic rocks there abundant.

Limestone can scarcely be said to occur in the plains or foot-hill belt, ^{Limestone.} except in the form of scattered boulders, transported thither in the glacial period, and occasionally in sufficient numbers to be locally useful. The massive limestones of the mountains must serve as the main source of supply of lime for the entire region. These are well situated for working where the railway enters the mountains, particularly in several places on the line between Kananaskis and a point eight miles west of that station. The eastern border of the Palaeozoic rocks, as defined on the map, may be said to be throughout composed of limestone, with the exception of a length of about twenty-eight miles northward from Waterton Lake, in which older silicious and slaty rocks—all probably of Cambrian age—are largely developed in the eastern range.

The occurrence of gold, which in some of the streams may be found ^{Gold.} to exist in remunerative quantity, is referred to on a subsequent page, in connection with the description of the drift deposits.

SUPERFICIAL DEPOSITS AND GLACIATION.

The superficial deposits, or those materials which, resting indifferently on the worn beds of the Cretaceous and Laramie, form the actual surface of the district now under description, are so largely those of the glacial age that to describe them is practically to outline the history of that very interesting period. In general the older rocks are deeply mantled with these deposits, and it is seldom, except in the neighbourhood of the mountains, that these appear, save in the deep ^{Influence of drift deposits.} river-valleys. The superficial deposits have, in fact, not only greatly modified the appearance of the country as a whole, but have given character to, and impressed a general uniformity on, the nature of its soil.

The general characters of the several deposits of the glacial period are, however, so similar, that it will not be necessary to enter in great detail into the description of localities. One of the most striking features, indeed, of the glacial deposits of the North-west is their extraordinary persistence and similarity of character over immense areas. Compared to their vast extent their thickness is almost infinitesimal, yet they everywhere characterize the surface in uninterrupted continuity for hundreds of miles.

As a part of the discussion of the superficial deposits of the plains ^{Previous notes on glaciation.} as a whole, in connection with the Boundary Commission exploration, I

have already given such facts as came under observation in the immediate vicinity of the 49th parallel, and while the greater knowledge of the district now obtained enables much to be added to these descriptions, it does not alter them in their main features.*

Pre-glacial
condition of
the country.

The pre-glacial aspect of the country has been much rougher and more diversified than that which it at present presents. It must have been for a very long time in the later Tertiary periods subjected to denudation, and deeply marked by rain and rivers. The glaciating agents have doubtless planed off many of these irregularities, and the surface has besides been deeply buried in its deposits, to which the general name of drift has been applied in the preceding parts of this report. These have been laid down in greatest thickness in the pre-existing hollows and low tracts, and the general effect has been a filling up of the asperities, and the production of wide areas of almost perfectly level prairie. That this has been the case is evidenced by the fact that while some of the higher plateaus and ridges are but scantily covered with drift, the thickness shown in many of the river sections is over two hundred feet.

Old and new
river channels.

Whatever the courses of the pre-glacial rivers (and there is no evidence that they departed widely from the present west-to-east system of drainage) the new streams which began to form channels for themselves when the glacial conditions had passed away, certainly did not follow the old beds. This is shown by the fact that while in some cases almost the entire height of the scarped banks along the streams is formed of Cretaceous and Laramie rocks, in others these banks are altogether composed of drift deposits, the base of which lies even lower than the present river-bed.

General thick-
ness of drift.

As a rough estimate of the importance of the drift deposits in the district, it may be stated that in the region east of the Porcupine Hills, they probably average at least one hundred feet in thickness.

The following is a list, in descending order, of the superficial deposits developed in the region under discussion :—

Table of
deposits.

- Stratified sands, gravels and silts.
- Upper boulder-clay.
- Interglacial deposit with peat.
- Lower boulder-clay.
- Quartzite shingle and associated beds.

Quartzite
shingle below
boulder-clay.

Resting immediately on the surface of the Cretaceous and Laramie, in a number of widely separated localities, is a deposit of well rolled pebbles or shingle, consisting for the most part of hard quartzites, and

* See Quart. Journ. Geol. Soc., Nov., 1875, and Geology and Resources of the 49th Parallel. 1875.



W. E. 83
D E 83

Geological Survey

DRIFT BLUFFS IN BELLY VALLEY - COAL BANKS CROSSING.

At A, quartzite shingle underlying Boulderclay. B, Lower Boulderclay. C, Interbedded shinnel sandy deposit overlain by Upper Boulderclay in distant tank.

derived entirely
Limestone is occa-
shingle as a whole
while on its east
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This quartzite a
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Wolf' Island. A
stratified sand and

The section here

1. Pale yellow
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Laurenti
3. Unstratified
diameter
4. Stratified
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5. Fine pale p
6. Stratified y
7. Quartzite
becoming
underlyin
8. Cretaceous
water)...

On the section
seen in a number
miles above High

* There is no admixture
eustern origin would be
associated rocks may have
far to the north, but in the
lithological characters—
the shingle, are precisely
they have been thence derived

derived entirely from the Paleozoic rocks of the Rocky Mountains.* Limestone is occasionally found in this bed near the mountains, but the shingle as a whole has evidently been subjected to such prolonged wear while on its eastward course, that this and other soft materials have been altogether ground down before attaining any very great distance from the place of origin. The pebbles are seldom more than a few inches in diameter, and are often very uniform in size, forming a closely packed bed, in which the stones are arranged with their longer axes parallel to the plane of deposit.

This quartzite shingle bed has been observed on the Old Man River below Fort MacLeod, in several places. It is entirely wanting on the upper part of the St. Mary River, appearing for the first time at a point six miles from its mouth. It may be seen on the Belly, on the right side of the valley near the trail-crossing at Coal Banks, and in several other places on its lower course, as at Big Island bend, the north-west angle of Drift-wood bend, and in the north bank opposite Wolf Island. At the last-mentioned locality it is associated with stratified sand and clay beds, a circumstance not elsewhere observed.

The section here is as follows, in descending order:—

	FEET.	
1. Pale yellowish-grey, more or less perfectly stratified boulder-clay, about.....	100	Section at Wolf Island.
2. Purplish, finely-bedded sandy clay, with thin layers of ironstone and a lignite bed eighteen inches thick. A few Laurentian pebbles near the base.....	8	
3. Unstratified boulder-clay, holding stones up to 2' 6" diameter.....	15	
4. Stratified yellowish and brownish-yellow sands, with a few stones, some of which are Laurentian.....	15	
5. Fine pale purplish-grey clay.....	4	
6. Stratified yellowish sands.....	6	
7. Quartzite shingle deposit, without Laurentian fragments, becoming clayey and full of derived fragments from underlying rocks at base (about).....	15	
8. Cretaceous shales and sandstones with eroded surface (to water).....	10	
	173	

On the section formed by the Bow River, the quartzite shingle is seen in a number of places. It was first recognised at a point a few miles above Highwood River, where it has a thickness of fifteen feet,

* There is no admixture of Laurentian or Huronian material, to which an eastern or north-eastern origin would have to be assigned. It is possible that a portion of the quartzites and associated rocks may have been originally derived from portions of the Rocky Mountains range far to the north, but in the absence of any evidence to that effect, and in view of the fact that the lithological characters—even some of a peculiar and exceptional kind—found in the pebbles of the shingle, are precisely those of the rocks of the mountains to the west, it is most probable that they have been thence derived.

Quartzite
shingle on Bow
and Red Deer
Rivers.

and is near the water-level. Below the Highwood it was seen at one place near the lower end of Pine Cañon at an elevation of sixty feet above the river. At a point, a few miles above the Arrow-wood Creeks, it has a thickness of fifteen to twenty feet, the base being about twenty feet above the water, and the summit capped by ten to fifteen feet of hard boulder-clay. About three miles above the Blackfoot Crossing it is again well shown. Its existence was also suspected at several points below the Blackfoot Crossing, but could not be proved owing to the extensive slides which have occurred in the banks. It was also recognized by Mr. McConnell at several places on the Red Deer River within the limits of the map.

Origin of
shingle.

The origin of the quartzite shingle is a question of great interest, but at the same time a very difficult one. It at first appeared to be certain that it must have been brought eastward from the mountains by rapid streams, of a date immediately preceding the glacial period, and that it must either still occupy the channels of these, or have been spread abroad in some wide body of waters into which they flowed. The discovery in the Cypress Hills, in 1883, by Mr. McConnell, of an extensive Miocene formation, the greater part of which is composed of precisely similar shingle more or less cemented together by calcareous matter, must now, however, be taken into account. It is possible that this formation which now caps the high plateau known as the Cypress Hills, at one time spread much more widely, and that its gravels have been re-arranged and spread over the neighbouring plains by pre-glacial streams as denudation proceeded, and further, that these Miocene beds may have supplied much of the quartzite material which enters largely into the composition of the boulder-clay and its derived deposits. The fact, however, that exactly similar quartzite gravels can be traced up into the foot-hills, in the valleys of some of the streams, forming a thin layer beneath the boulder-clay, where there is no evidence whatever of the existence of any Miocene beds, tends to prove that a portion, at least, of the quartzite gravels here referred to, have been derived immediately from the mountains, in times just preceding, or marking the initiation of, the glacial period. The question is one admitting of much additional investigation.

Miocene
conglomerates.

Two sources of
supply.

Irregularity in
distribution of
shingle.

The level of these pre-glacial gravels, often differs very considerably in the river sections, as compared with the water-level of the modern rivers. The gravels, however, tend generally to characterize the lower parts of the district, and are, for example, quite wanting along almost the entire course of the St. Mary. They are by no means universally spread even in the parts of the district which they characterize, a fact which may be due either to an original irregularity in distribution, or to their subsequent partial removal and mingling with

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the general substance of the drift of the glacial period. No glaciated stones were anywhere found in these gravels, and the line between them and the boulder-clay is usually a perfectly distinct one. The only section which shows a blending with the base of the boulder-clay is that already quoted at Wolf Island, apart from which the shingle might be regarded as a deposit referable to the last stage of the Tertiary.*

The boulder-clay, which constitutes by far the most important member of the drift deposits, is very variable in thickness, having in some places a volume of nearly two hundred feet, while in others it is quite thin. It presents the usual characters of this deposit, being, as a rule, a hard sandy clay, containing a variable and often very considerable proportion of Laurentian and Huronian erratics, mingled with fragments of quartzites from the Rocky Mountains, and sandstone blocks from the Cretaceous or Laramie. The mass of its finer components, however, usually appears to have been derived from the beds underlying it at no great distance, and has been formed of these materials ploughed up and kneaded together. In consequence of this circumstance its colour varies considerably, ranging from dark blackish or bluish-grey to lighter tints of the same, and often becoming yellowish-grey or fawn-coloured, especially where weathered. On the St. Mary, it was observed to have in some places a distinctly reddish tint, due to the colours of the neighbouring reddish clays of the Willow Creek subdivision of the Laramie. Where shown in good sections, it is generally divisible into an upper and lower part, the latter being more compact, and though not without stratification planes, showing them in a less marked manner, while the former is, as a rule, not only more distinctly stratified but also less compact. This feature is specially well shown on the Belly River below Coal Banks, and between the upper and lower boulder-clays the remarkable sedimentary deposits, described in a succeeding paragraph, here occur.

The boulder-clay.

Colour.

Upper and lower parts.

The boulder-clay, from its massive character, frequently weathers in Distribution.

* Since the above was written, Mr. J. B. Tyrrell, in the course of the geological examination of the country north of the Red Deer River, has found gravels or incoherent conglomerates capping the Hand Hills, precisely like those of the Cypress Hills. These have yielded no fossils but there can be little doubt that they are like those of the Cypress Hills, of Miocene age. This discovery appears to show that the Miocene shingle-beds may have been much more widespread and important than previously supposed, though but occasional remnants of them, capping the higher plateaus, are now found. It may even be, that in the distribution of the quartzite gravels above described as underlying the boulder-clay, we have a general definition of the area of the Miocene formation, the immediately pre-glacial gravels having resulted from its waste, and accumulated in the valleys of streams which ran through the old Miocene area. It must still, however, be admitted that similar gravels underlie the boulder-clay near the mountains, and that these have probably no connection with the denudation of Miocene beds, but have been derived directly from the mountains. The question of the mode of transport of so great a quantity of coarse gravel to such a great distance from its source in the mountains, and its deposition on the soft beds of the plains in Miocene times, without any evidence of ice action, is a very difficult one.

river-cliffs into prismatic and columnar forms, and it is this deposit which is concerned in most of the heavy land-slides which occur along the valleys of the streams. It may be regarded as entirely covering by far the larger part of the surface of the district, but on approaching the base of the mountains is replaced by morainic accumulations due to local glaciers. Certain tracts characterized by the presence of a great thickness of boulder-clay have already been alluded to in the general description of the river sections. It rests often directly on the Cretaceous and Laramie rocks, even in the immediate neighborhood of localities where the intervening shingle deposit was observed well developed, and its base is often below the level of the water, even in the deeper river-valleys.

Interglacial
beds.

The intercalated finer beds, above alluded to, are well shown in the section at Wolf Island (p. 141 c). They are seen also in a number of places on the Belly between Wolf Island and Coal Banks, and the body of water in which they were laid down must have been a very extensive one. On the east side of Drift-wood bend, seven miles west of Wolf Island, the following section occurs:—

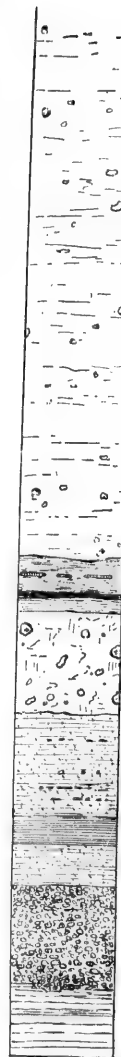
Section at
Drift-wood
Bend.

	FEET.
1. Boulder-clay, with traces of stratification, to top of bank....	40
2. Finely stratified, pale-grey sand, with irregular lenticular masses of soft ironstone, a few inches thick.....	15
3. Brownish-grey, earthy, sandy clay, distinctly stratified, with carbonaceous layers, which in places become impure lignite; small selenite crystals and concretions. 3' or more (variable.).....	3
4. Grey, fine sand with ironstone concretions, (like No. 2)	15
5. Massive boulder-clay with large stones and boulders, sometimes distinctly glaciated. Laurentian and quartzite fragments (to foot of bank)	80
	153

Interglacial
peat.

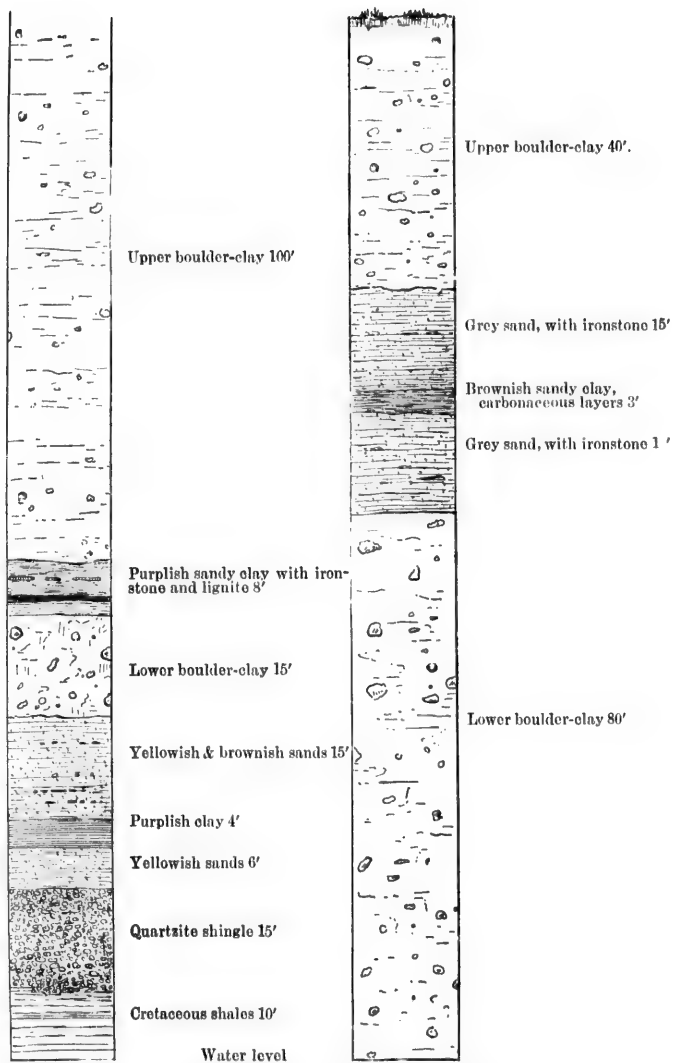
Four miles further up the Belly, at the north-west angle of Drift-wood bend, the same beds are again shown, but the carbonaceous layers have here coalesced to form a distinct bed, about a foot thick, of imperfect lignite or indurated peat. A specimen collected here has been examined by Mr. C. Hoffmann. It is very strongly acted on by caustic potash, affording a dark-brown liquid. On analysis by the method adopted for the Cretaceous and Laramie fuels it yielded the following results:—

Hygroscopic water.....	7.74
Volatile combustible matter.....	23.13
Fixed Carbon.....	22.05
Ash.....	47.08
	100.00



Section at Wolf
Island (p. 141 c).

SECTIONS ON T
BOULDER



Section at Wolf Island (p. 141 c.)

Section on east side Drift-wood Bend (p. 144 c.)

SECTIONS ON THE BELLY RIVER ILLUSTRATING RELATIONS OF UPPER AND LOWER BOULDER-CLAYS, INTERGLACIAL DEPOSITS AND QUARTZITE SHINGLE.

In the approach to the carbon, and its large proportion of high quality of peat.

Overlying the distribution of the tracts of level peat soil consisting of the slopes of the beds overlying the re-arrangement indicated by the features characterizing the surface of the elsewhere to overlie below and sandy over most of the yellowish-grey in

Along the base of the degraded conditions of the glaciers which deposit material of these materials the boulder-clay pebbles are entirely of Recent origin of hardness, the glacial far as observed the

On the Waterton moraine about ten miles from some miles below the moraine of the Waterton same character, with the ing from and scattered lake and opposite the lake miles northward and occurrence, and each character of the features giving issue to a large lateral moraines, some base of the mountain

The Bow River mountains tributary than any elsewhere several places some

In the approximate equality of volatile combustible matter and fixed carbon, and its percentage of water (when allowance is made for the large proportion of ash) this material resembles a poor lignite or good quality of peat.

Overlying the boulder-clay are wide-spread stratified deposits, the distribution of which assists materially in giving uniformity to the tracts of level plain. It is, indeed, quite exceptional to find the surface soil consisting of boulder-clay disintegrated in place, and this occurs only on the slopes of plateaus, or in hollows formed by denudation. That the beds overlying the boulder-clay have not been merely formed by its re-arrangement in water without the addition of new material, is indicated by the fact that in many places erratics much larger than those characterizing the boulder-clay of the locality are found strewn over the surface of the country. The beds observed in river sections and elsewhere to overlie the boulder-clay are generally gravels or sands below and sandy or clayey loams above. The latter form the subsoil over most of the region, and are generally rather pale brownish- or yellowish-grey in colour.

Along the base of the Rocky Mountains, moraines, in a more or less degraded condition, are abundant, and evidently due to considerable local glaciers which debouched from the present valleys of the range. The material of these moraines, when seen in section, differs considerably from the boulder-clay proper, not only in the fact that the included fragments are entirely of Rocky Mountain, or local origin, but in its greater degree of hardness, the greater roughness and angularity of the stones, and so far as observed the complete absence of bedding.

On the Waterton River, moraine material of this kind was first seen about ten miles from the base of the mountains. West of the river, for some miles below the lake, a ridge which has evidently been a lateral moraine of the Waterton Lake glacier, occurs; and several hills of the same character, with large blocks derived from the mountains protruding from and scattered over them, are found about the lower end of the lake and opposite the valley of the South Kootanie Pass. For about thirty miles northward along the base of the range, moraines are of constant occurrence, and can easily be recognized owing to the sparsely wooded character of the foot-hill belt in this region. Each little valley now giving issue to a brook, has formerly contained a glacier, and the old lateral moraines, sometimes still very well preserved, run off from the base of the mountains like spurs.

The Bow River valley, in correspondence with the large area of mountains tributary to it, appears to have held a glacier of larger size than any elsewhere originating in the mountains in this district. In several places some miles up the pass the rocks bear traces of heavy

Deposits
overlying
boulder-clay.

Moraines
distinguished
from boulder-
clay.

Moraines near
the mountains.

Bow valley
glaciers.

glaciation, and at "the Gap" the limestone is deeply grooved and fluted by the passage of ice. Near and above Morley, portions of lateral moraines of this glacier project through terraces of later date as ridges, parallel to the direction of the valley.

Between Morley and Calgary on the Bow, a deposit more closely resembling boulder-clay than true morainic matter was observed in several places, but the stones in it are entirely those of the mountains or sandstone blocks from the underlying beds.

Terraces and
planes of
denudation.

Terraces are prominent features in some parts of the river-valleys in this district, but are generally clearly due to the action of the river itself at a former period. The extensive tracts of almost perfectly level prairie which occur, afford evidence of water action of some duration, and may be regarded as wide terraces. The eastern face of the Porcupine Hills appears from a distance to be very distinctly terraced, but this aspect was found to be due to the outcrop of the nearly horizontal sandstone beds. On approaching the mountains, however, true terraces of a more significant character present themselves in many places. Terraces in the entrance to the South Kootanie Pass at a height of about 4,400 feet have already been described in my Boundary Commission report. In the valleys of Mill and Pincher Creeks, and those of the Forks of the Old Man, east of the actual base of the mountains, wide terraces and terrace-flats are found, stretching out from the ridges of the foot-hills, and running up the valleys of the various streams. Actual gravelly beaches occasionally mark the junction of the terraces with the bounding slopes, and they have no connection with the present streams, which cut through them. The level varies in different localities, but the highest observed as well characterized attains an elevation of about 4,200 feet.

Highest
terraces.

Terraces in
Bow Valley.

In the Bow Valley near Morley, and thence to the foot of the mountains, similar terraces are found which are quite independent of the modern river; and in the wide mouth of the valley of the Kananskis Pass a series of terraces were seen from a distance, which must rise to an elevation of at least 4,500 feet.

Terraces in the
mountains.

In the Bow and Crow Nest Passes, within the first range of the mountains, terraces are in many places well developed, but as local conditions, such as the stoppage of these valleys by transverse glaciers, may account for the existence of water at the elevations they mark, they do not possess so much interest as those above described.

Laurentian and
Huronian
boulders.

Western limit.

The occurrence of Laurentian and Huronian fragments in vast numbers as erratics over the district now described, at such a great distance from the nearest points of outcrop of the parent rock, and at elevations so considerable, is a matter of much interest. The western limit of the Laurentian and Huronian drift may be said to reach the base of the

DAWSON.]

Rocky Mountains. These rocks were found in a lake, within the valley, at an elevation of about 4,000 feet. Old Man, Laurentian boulder was found at the mill on the river, leading to the conclusion that it is however, observed by the higher Laurentian or Huronian after their first appearance, the height of the western limit of the contour-line of the South of the Benton, on the thickly strewn stones were and doubtless of in larger or smaller Laurentian rocks. The highest portion, however, particularly granite boulders, quartz, which I derived from so Marias the conditions identical with the report. In this entire Laurentian and Huronian boulders, which do not schists. The actual height found are in some cases may be not within fifty feet, regular barometer kindly supplied by forming the south-western limit crossed by the river.

Rocky Mountains, in the vicinity of the 49th parallel, for fragments of these rocks were found on the Waterton River two miles below the lake, within three miles of the actual edge of the Palæozoic rocks, and at an elevation of 4,200 feet. Northward, on the head waters of the Old Man, Laurentian drift is found, though sparingly, as far west as the mill on Mill Creek, at a height of 3,800 feet, and a single Laurentian boulder was seen about half a mile west of Garnett's, near the trail leading to the Crow Nest Pass, at a height of about 4,200 feet. I did not, however, observe any Laurentian drift on the North Fork of the Old Man, and it is probable that it is absent or nearly so in the district sheltered by the higher parts of the Porcupine Hills. On the Bow River no Laurentian or Huronian erratics were seen west of Calgary, and even after their first appearance they are very scarce for some distance. As the height of the Bow River at this point is only about 3,300 feet, the western limit of the Laurentian drift cannot conform strictly to any contour-line of the present surface of the country.

South of the 49th parallel, the country travelled over from Fort Benton, on the Missouri, by the MacLeod trail, is all more or less thickly strewn with Laurentian erratics. South of the Marias River, the stones were observed to be chiefly quartzites of varying colours and doubtless of Rocky Mountain origin, but with these are mingled in larger or smaller proportion, granitic, gneissic and schistose Laurentian rocks, and these occur equally in the river-valleys and on the highest portions of the plains crossed by the trail. There is also, however, particularly in the vicinity of the Missouri, a proportion of granite boulders with flesh-purple felspar and bluish, rather opalescent quartz, which I did not recognise as Laurentian, and which may be derived from some not far remote mountain region. North of the Marias the conditions continue similar, and are, in fact, practically identical with those of the region more especially treated in this report.

In this entire district there is no possibility of confounding the Laurentian and Huronian erratics with those from the Rocky Mountains, which do not afford any granitic or gneissic rocks or crystalline schists.

The actual heights at which Laurentian and Huronian erratics are found are in some instances very great. A few of the more striking cases may be noted. The heights given are probably trustworthy to within fifty feet, having been worked out by comparison with the regular barometric observations at Fort Benton, which have been kindly supplied by General Hazen.—At the summit of the high ridge forming the southern continuation of the Porcupine Hills, which is crossed by the road between Fort MacLeod and Pincher Creek at an

Drift deposits
in northern
Montana.

No crystalline
rocks in the
mountains.

Great elevation
of Laurentian
and Huronian
erratics.

elevation of 4,390 feet, Laurentian stones were found, though not abundant. In 1883 several indubitable Laurentian boulders, representing three varieties of granitic and gneissic rocks, were found about twenty miles north of the 49th parallel, at an elevation of 5,280 feet. They occur on the summit of a high ridge, which is evidently of morainic origin, within a few miles of the Palaeozoic rocks of the mountains, but for the reasons elsewhere given they can not have been derived from these mountains, and their origin must be sought with that of those so numerous at lower levels, to the east or north-east. This is the highest point at which Laurentian boulders have been found in the district. Numerous similar erratics are found on the high country near the Milk River, and between that stream and the St. Mary River, about the intersection of the 49th parallel and 113th meridian, at an elevation of about 4,200 feet.

No drift on
summit of
Rocky Spring
Plateau.

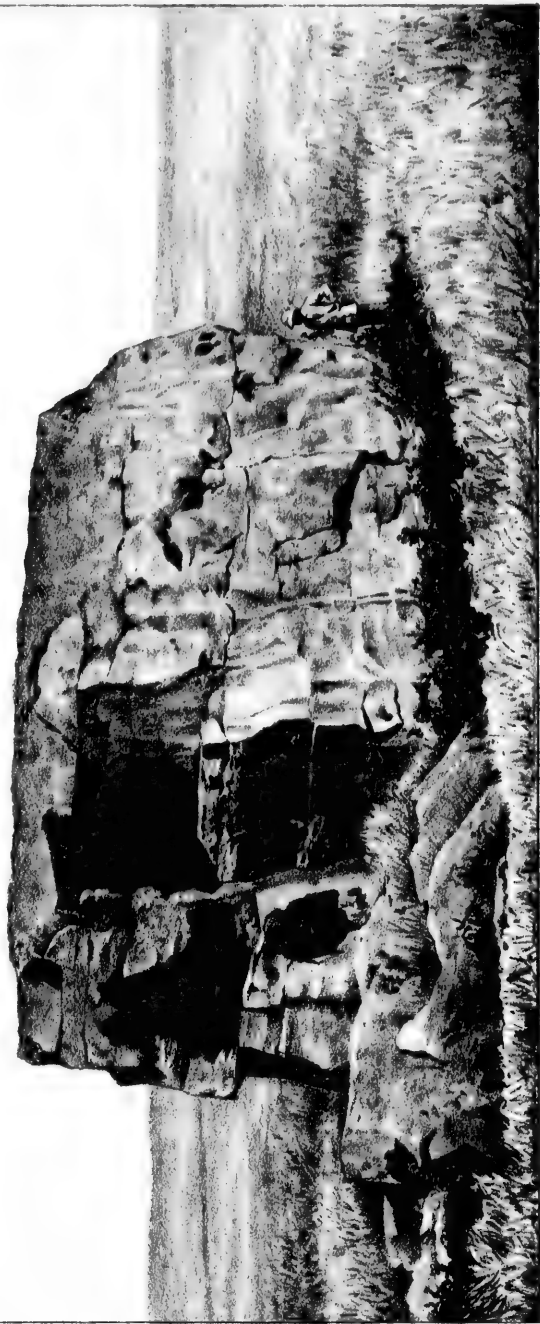
A few miles south of the 49th parallel, on the MacLeod-Benton trail, the Rocky Spring plateau is crossed. The south-eastward front is a steep escarpment facing a comparatively low plain, and is very thickly strewn with Laurentian and Huronian erratics as though it had at one period constituted a shore-line. Northward, the plateau slopes gradually down from its greatest elevation of 4,176 feet. The highest point of the plateau, crossed by the trail, is, for a mile or more, quite without drift deposits or erratics, but before any considerable descent is made to the north, erratics become abundant, though not large, and much resemble the remains of an old beach deposit. The height of the Laurentian drift here is about 4,100 feet. From other observations it is certain that this elevation does not constitute the limit in height of the Laurentian material, and it seems possible that the summit of this plateau was occupied by a snow-field during glacial times which prevented the accumulation of the deposits elsewhere found.

Erratics on
flanks of Sweet
Grass Hills.

The Three Buttes, forming isolated high summits in the centre of a wide plain, offer peculiar facilities for the determination of the highest points attained by the glaciating agent and Laurentian erratics. Much more time might profitably be employed in the investigation of the facts here than I was able to spare. In 1881 an examination of the western flanks of the West Butte, however, proved that Laurentian boulders of small size, with cream-coloured limestone resembling that of the Winnipeg basin, are abundant at an elevation of 4,600 feet, while the highest observed Laurentian fragments attained a height sixty feet greater.

Occasional
great size of
boulders.

Very large boulders were noted in a few places in the district. A remarkable group of these, composed of Huronian quartzites, occurs near the lower part of the Waterton River, and it is notable generally that some of the heaviest boulders are found not far from the western



BOULDER OF HURONIAN QUARTZITE, NEAR WATERTON RIVER.

U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C.

limit of the Laurentian
 $42 \times 40 \times 20$ feet
 the soil. The height
 must be between
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 depression, caused
 worn quite smooth
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While the main
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 Two theories only
 glacier, occupying
 the Hudson's Bay
 Rocky Mountains

limit of the Laurentian and Huronian drift. One of these erratics is $42 \times 40 \times 20$ feet, a second $40 \times 30 \times 22$, and both are partly buried in the soil. The height of this point was not exactly determined, but must be between 3,200 and 3,300 feet. In common with all the larger boulders of the district these are surrounded by a shallow saucer-like depression, caused by the pawing of the buffalo, and their angles are worn quite smooth and glossy by the rubbing of these animals upon them.

While the main river-valleys whether on the area of the plains or in the foot-hills and Porcupine Hills, evidence very considerable post-glacial erosion, the general surface of the plain country east of the Porcupines seems to have suffered very little in this respect since the waters, (which under any hypothesis must have covered it at least at the close of the glacial period), left its surface. In the numerous lakes and pools occupying shallow depressions and without defined outlet, in the entire absence over considerable areas of drainage channels, and their general infrequency, evidence appears to be given that the rainfall of the eastern portion of the district has been continuously very small since the glacial period. Wherever the surface has locally been considerably lowered by denudation, great numbers of boulders appear, and their comparative rarity over great portions of the plains can be due only to the persistence of the finer surface covering since glacial times.

Theoretical conclusions as to the mode of glaciation of this district have, as far as possible, been excluded from the foregoing summary of the facts. Apart from the local glaciers of the Rocky Mountains, it is evident that it has been accomplished by some agent moving westward or south-westward from the Laurentian axis which bounds the region of the Great Plains to the east. This agent has carried with it great quantities of Laurentian and Huronian material, which in the vicinity of the 49th parallel reaches at its extreme limit a point over 700 miles distant from the nearest exposures of the parent rock, and to an elevation more than twice as great as that attained by any part of the Laurentian area. To explain this latter fact it seems now almost certain that we must assume that the western region was, in glacial times, relatively to the Laurentian area more depressed than at present. As I have elsewhere, in the publications before referred to, discussed at some length the question whether a glacier or floating ice best accounts for the facts, it is not here proposed to recapitulate the arguments. Two theories only, however, seem tenable. Either a great confluent glacier, occupying the Laurentian highlands or passing over them from the Hudson's Bay region, stretched continuously to the slopes of the Rocky Mountains, or such a glacier, extending but a limited distance

Post-glacial
denudation.

Mode of
glaciation of
the Great
Plains.

from these highlands, supplied numerous and massive icebergs which floated in a great inland sea occupying the present position of the plains.

Significance of
old drainage
channels.

I still believe that the latter supposition best accounts for the facts of the glaciation and glacial deposits of the plains. I would, however, point out one circumstance which seems to give some colour to the former hypothesis. This is the existence of a number of wide, old, abandoned water-channels, which may be supposed by this theory to have carried the drainage of the country, and water produced by the melting of a great glacier of the kind implied, round its front at different periods in its retreat. The existence of these I am unable otherwise satisfactorily to explain, except on the supposition of considerable relative changes of level of different parts of the district in post-glacial times. Mr. Warren Upham has lately traced a number of such channels in Dakota (hypothetically extending his reasoning also to western Manitoba), for which he accounts by the first-mentioned or great-glacier theory.

Great coulées.

In the southern part of the district of the present report, and particularly in the country south of the Belly River, great old channels of the kind above referred to are displayed in a very striking manner in Verdigris, Etzi-kom, Pā-kow-kī, and Chin Coulées and their tributaries. These resemble old river-valleys long disused and now carrying little or no water. I am inclined to regard them as a portion of the earliest drainage system of the plains, outlined at the time at which the waters which distributed the stratified materials overlying the boulder-clays first subsided, and when the rainfall of the region was considerably greater than at present. That these first channels have not, in the particular part of the region now referred to, continued to be the drainage-channels of the country, is perhaps in part due to the much greater depth and importance rapidly attained by the valleys carrying copious and perennial streams derived from the mountains. In the entire obliteration of the original south-eastward slope of the valleys of Verdigris and Pā-kow-kī Coulées, and other peculiar circumstances referred to, in a previous part of this report (p. 14 c) in connection with their present aspect of Milk River, as well as in several local details respecting the relations of the present drainage and the old channels, we appear to find evidence of a greater amount of elevation of the southern as compared with the northern part of the district.* So far as it has affected these old drainage-channels this must have occurred in immediately post-glacial times, and may have been a continuation of the same process which has resulted in the present much greater elevation of erratics in the southern as compared with the northern part of the region.

Greater
post-glacial
elevation to the
south.

* See also *Geology and Resources of the 49th Parallel*, p. 264.

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Unless explained by relative differences in level during the glacial period, such as those above suggested, between the Bow River country and that near the 49th parallel, the absence of Laurentian erratics, over the region west of Calgary can only be accounted for by the existence of Rocky Mountain glaciers of sufficient size in this region to fend off the eastern glaciating agent. It is not improbable that such glaciers obtained, and if they can be proved to have existed, it would also prove, in the most convincing way, the approximate contemporaneity of action of the glaciating agents of the Rocky Mountains and Laurentian region. It is certain, however, that the glaciers of the mountains had somewhat decreased before at least the final period of dispersion of Laurentian erratics, for these have been found overlying distinct morainic material of Rocky Mountain origin.

That the elevation of the western as compared with the eastern part of the plains, was relatively much less in glacial times than at present, seems a reasonable supposition, but must be regarded no longer as merely an hypothesis, for the position of the interglacial materials in the boulder-clay offers a strong positive argument in its favour. It must be supposed that these beds, from their finely stratified character and evidences of tranquil deposit, were laid down, not along the gradually retreating edge of a lake, but in the bottom, and at depths not very considerable. This being the case, the deposits give us the means of recognizing a surface—that of the lake bottom—which was at least approximately horizontal during the interglacial period at which they were formed. From Wolf Island to Coal Banks, the two points furthest apart at which the deposits were observed, is a distance of forty-five miles in a direct line, on a bearing of about S. 70° W. The height above the river of the deposits at the former locality is seventy feet, at the latter, one hundred and five feet, giving a slope eastward of 0.77 feet per mile in addition to that of the present river bed. The latter may be assumed as indicating that of the present surface of the country, as a whole.

The elevation of the beds in the intermediate Drift-wood bend section is about ninety-six feet, but the locality is only about six miles westward on the same line, and the resulting slope per mile is 4.3 feet, in addition to that of the river, in the same easterly direction, a rate of fall locally much greater than that above determined for the whole distance.

The rate of fall of the Belly River, by its course, between Coal Banks and its mouth, is 6.8 feet to the mile, but on the line above defined (which is that of its general direction) between Wolf Island and Coal Bank, 12 feet to the mile. Adding the general slope previously ascertained for the intercalated beds, we find their eastward inclination to be 12.77 feet to the mile.

Proof of great
uplift of
western region.

Plane of
interglacial
deposits.

General east-
ward slope of
plains produced
in post-glacial
times.

The general eastward slope of the plains from the base of the mountains to that of the Laurentian region at Lake Winnipeg is about 5 feet to the mile, but the elevation increases more rapidly westward and in the region now considered; and if the intercalated beds referred to were again brought back to horizontality, the plains between the mouth of the Belly River and Coal Banks would become nearly horizontal also.*

Distribution of
placer gold.

Besides the effect of the glaciation of the country on its soils and general features, a further result of economic importance in connection with this period is the distribution of gold. Dr. Selwyn in 1874† expressed the belief, based on an examination of the country near Edmonton, that the gold found in the rivers of the Great Plains has been derived from the Laurentian and Huronian region to the east, and not from the Rocky Mountains. The facts met with in the district now reported on conclusively prove the correctness of the above statement. In favourable spots on all the streams of which the banks and beds show abundance of Laurentian and Huronian drift, fine gold may be obtained, while beyond the edge of this drift in the immediate vicinity of the mountains, I have never been able to detect a "colour."

It would be premature to state positively that none of the streams in the mountains yield gold. It is possible that local auriferous deposits may occur, though from the nature of the rocks so far observed in the eastern ranges, not very probable. The general auriferous character of the rivers of the plains depends, however, on the distribution of gold, usually in a very fine state, which has been derived from the old crystalline rocks of the Laurentian and Huronian. In the Bow and Belly district no systematic attempt has yet been made to work the placer deposits on the rivers.

* In the region west of the Missouri, the present inclined position of the Pliocene beds shows that since the time of their disposition that part of the region in the vicinity of the Rocky Mountains has been greatly elevated. It may well be that the eastward slope of the portion of the plains here treated of may have been produced as a result of the same great movement, and if so the facts above recorded would assign it a date subsequent to that of the glacial period.

† Report of Progress, 1873-74, p. 58.

The following list
Canadian Pacific R.
ing this report:—

South Saskat
Stair
Bowell
Suffield
Langevin
Kininvie
Tilley
Bantry
Cassils
Southesk
Lathom
Bassano
Crowfoot
" (Cre
Cluny
Gleichen
Namaka
Strathmore ..
Cheadle
Langdon
Shephard
Calgary
" (River
Keith
Cochrane
Radnor
Morley
Kananaskis ..
Bow River—W
tains ("T

APPENDIX I.

LIST OF ELEVATIONS.

The following list comprises the stations on the portion of the Canadian Pacific Railway within the limits of the map accompanying this report:—

	FEET ABOVE SEA LEVEL.
South Saskatchewan River at Medicine Hat	2,101
Stair	2,403
Bowell	2,559
Sutfield	2,431
Langevin	2,471
Kininvie	2,405
Tilley	2,438
Bantry	2,449
Cassils	2,493
Southesk	2,477
Lathom	2,534
Bassano	2,563
Crowfoot	2,672
“ (Creek)	2,715
Cluny	2,823
Gleichen	2,926
Namaka	2,945
Strathmore	3,005
Cheadle	3,165
Langdon	3,268
Shephard	3,344
Calgary	3,388
“ (River level)	3,366
Keith	3,522
Cochrane	3,712
Radnor	3,825
Morley	4,032
Kananaskis	4,170
Bow River—Water level at point of issue from the mountains (“The Gap”)	4,100

ELEVATIONS BAROMETRICALLY DETERMINED.

The elevations of the following points have been determined with some accuracy by one or more selected readings of aneroid barometer, compared with the regular observations of the mercurial barometer at Fort Benton, corrected by interpolation to correspond with the hour at which each of the aneroid readings was made. The height of the observing point at Benton is taken at 2,700 feet. I am indebted to General W. B. Hazen, Chief Signal Officer, U.S.A., for a copy of the observations at Fort Benton.

*Principal Elevations Barometrically Determined, 1881.**MacLeod-Benton Trail.*

	FEET ABOVE SEA LEVEL.
Plain N. of Marias R., Montana.....	3,007
Plain immediately S. of Rocky Spring Plateau	3,322
Camp at spring, Rocky Spring Plateau	3,659
Summit of Rocky Spring Plateau.....	4,176
Camp at Red Creek Crossing (water-level)	3,549
Milk River Crossing (water-level)	3,546
Lake at 9-Mile Butte	3,514
Ed. Mahan's Coulée (water-level).....	3,449
Lake at 15-Mile Butte	3,082
"Coal Banks," Belly River (water-level)	2,717
Fort MacLeod (water-level).....	3,096

Confluence Bow and Belly Rivers (water level).....	2,212
Camp, prairie 4 m. W. of Seven Persons' R., 9 m. N. of Cypress Trail	2,640
Seven Persons' River, trail-crossing (water-level).....	2,673
Plain 10 m. S. of Crossing, long. 111°	2,676
Crest of ridge N. of L. Pa-kow-ki, long. 111°	2,811
Lake Pa-kow-ki (water-level)	2,735
Milk R. at Pa-kow-ki Coulée (water-level)	2,816
Flank of W. Butte. (Laurentian drift abundant).....	4,601
" " (highest observed Laurentian drift)	4,662
Milk R. at Verdigris Coulée (water-level)	3,065
Milk R. 20 m. W. of MacLeod-Benton trail-crossing (water-level)	3,720
Milk R. 1 m. N. of 49th parallel, long. 113° (water-level)	4,173
Camp at two lakes 5 m. W. of above point.....	4,116
St. Mary R. 6 m. N. of 49th parallel (water-level)	3,850
Waterton R. near mouth (water-level)	3,217
Waterton Lake	4,245

S. Branch Dr
Southern stre
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E. base of Su
Summit of S.
Summit of pe
Calgary Trail
Highwood R.
Blackfoot Cro
Middle Fork
level)....
Crow Nest L
Summit Crow
Camp 3 m. W
Camp W. bas
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N. Fork Old
level)....
Little Bow at
level)....
Camp summi
Lake in Snak
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Camp at S. b
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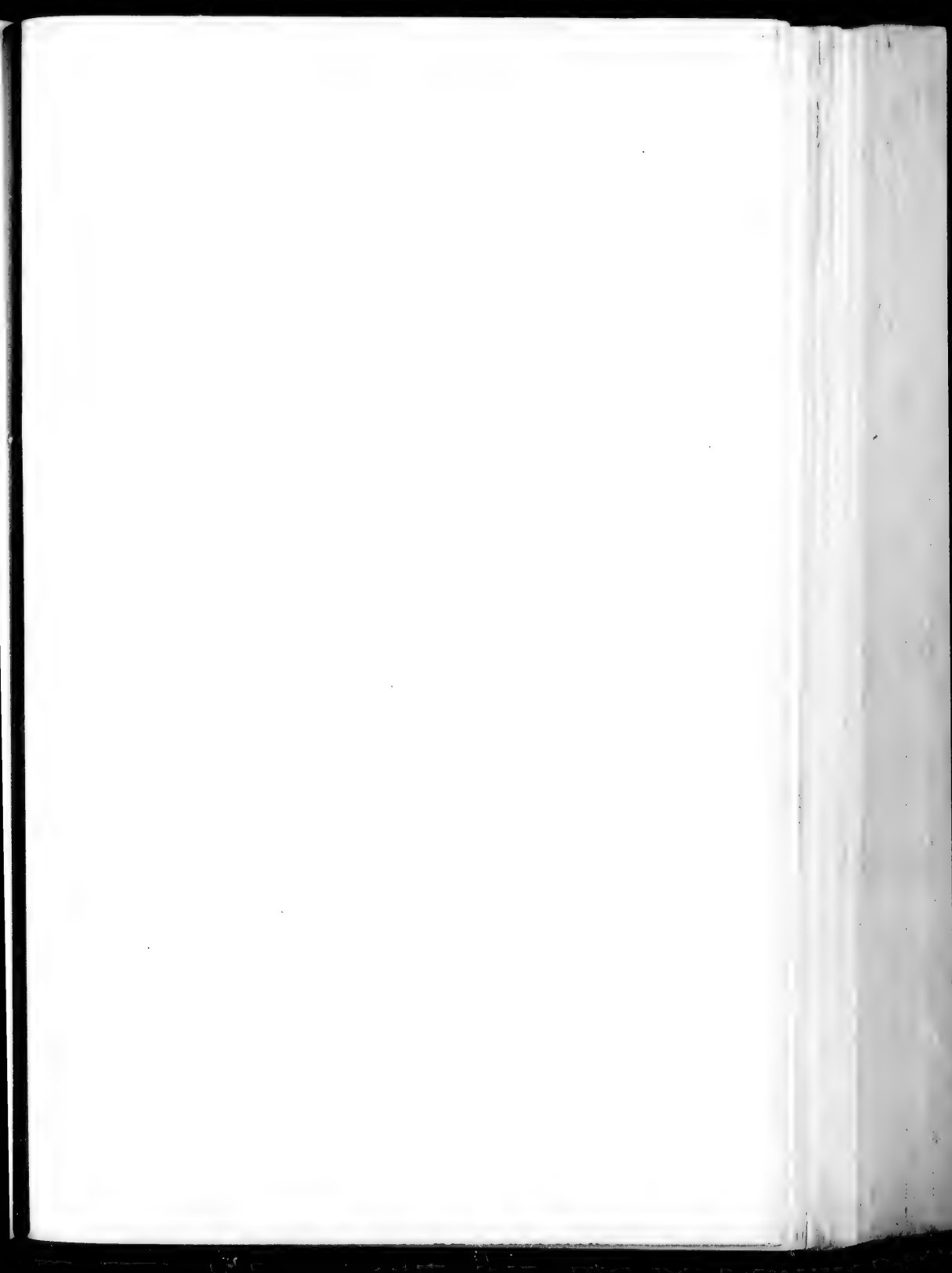
Plains 6 m. N
" 11 m.
" 18
" near S
" 13 m.
" 8
Suds Lake, V
Middle Coulé
Camp in valle
Nine-Mile Bu
Fifteen-Mile
Coal Banks, 1
Summit N. K
Summit S. K
Garnett's Ho
Middle Fork

S. Branch Drywood Fork at issue from mountains.....	4,711
Southern stream of N. Branch Drywood Fork $\frac{1}{2}$ m. W. of edge of Palaeozoic rocks.....	4,892
Mill on Mill Creek (water-level below dam).....	3,807
Kootanie Brook at Forks in S. Kootanie Pass.....	4,703
E. base of Summit Ridge, S. Kootanie Pass.....	5,701
Summit of S. Kootanie Pass on trail (approx.).....	7,070
Summit of peak 1 m. N. of S. Kootanie Pass.....	7,878
Calgary Trail 4 m. S. of Pine Coulée.....	3,240
Highwood R. at trail-crossing (water-level).....	3,383
Blackfoot Crossing of Bow R. (approximate only).....	2,595
Middle Fork Old Man R. at issue from mountains (water- level).....	4,170
Crow Nest Lake, in Pass.....	4,426
Summit Crow Nest Pass (5 m. W. of first watershed)..	4,853
Camp 3 m. W. of summit Crow Nest Pass.....	4,533
Camp W. base of Porcupine Hills, about 40 feet above N. Fork of Old Man R., at angle.....	4,116
N. Fork Old Man R. at issue from mountains (water- level).....	4,437
Little Bow at crossing of Blackfoot Crossing trail (water- level).....	3,053
Camp summit of Buffalo Hill.....	3,857
Lake in Snake Valley ..	2,872
Camp near summit level of Rocky Buttes.....	2,972
Camp at lake on plain at S. E. base Rocky Buttes.....	2,650
Camp at S. base of Black Spring Ridge.....	3,030
Camp on plain near Scabby Butte.....	3,112
Mouth Little Bow R. (approximate only).....	2,578
Summit of Hog's Back on trail W. of Ft. MacLeod.....	4,390

Principal Elevations Barometrically Determined in 1883.

	FEET.
Plains 6 m. N. E. of mouth of Pa-kow-ki Coulée.....	2,892
" 11 m. N. of E. end Dead Horse Coulée.....	3,050
" 18 " " ".....	2,967
" near S. bend Etzi-kom Coulée.....	2,971
" 13 m. N. W. of mouth of Verdigris Coulée.....	3,000
" 8 " " ".....	3,030
Suds Lake, Verdigris Coulée.....	3,060
Middle Coulée at trail-crossing.....	3,117
Camp in valley of stream near head of Fossil Coulée..	3,460
Nine-Mile Butte Lake.....	3,540
Fifteen-Mile Butte Lake.....	3,096
Coal Banks, Belly River.....	2,655
Summit N. Kootanie Pass.....	6,690
Summit S. Kootanie Pass (mean of obs. of 1881-83)....	7,040
Garnett's House, near S. Fork Old Man.....	4,160
Middle Fork Old Man, trail-crossing.....	3,904

Crow Nest Lake (mean of obs. of 1881-83).....	4,387
Summit Crow Nest Pass (5 miles W. of first watershed)	4,838
" " " (mean of obs. of 1881-83).....	4,845
Camp in valley at E. foot Livingstone Range, 10 m. S.	
of North Fork Gap	4,920
North Fork Old Man River (inside Gap).....	4,600
North Branch North Fork Old Man R., 2 m. from Gap.	4,709
" " " " " 16 "	5,371
N.W. " " " " " 8 "	4,966
" " " " " (above fall) ...	5,512
Camp in valley in foot-hills 6 m. S. of N. Fork Old Man	4,670
Mouth S. Branch S. Fork of Old Man	4,239
Small lake in foot-hills near Upper Pincher Creek	4,751



APPENDIX II.

BLACKFOOT NAMES OF A NUMBER OF PLACES IN THE NORTH-WEST TERRITORY, FOR THE MOST PART IN THE VICINITY OF THE ROCKY MOUNTAINS.

Note.—The names in these lists were received from Mr. J. C. Nelson, who, in association with Mr. A. P. Patrick, was during several years engaged in surveys in the North-west. The phonetic values of the letters are not exact, and have been indicated by transcription to make the orthography conform to any phonetic system. It appears, nevertheless, desirable to place the original Indian names of places on record as far as possible.

PLACES WITHIN THE AREA COVERED BY THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
Slide Out.....	eh-pit-seht-zoaskoi.....	Point of timber running out.
Big Island (at Forks of Belly and Waterton R's).....	oh-max' inay.....	The lake in the pound.
Little Owl Lake (middle of Waterton Lakes).....	se-pisto-maxi-kimmi.....	Naked river.
Little Bow River.....	namagh-ty.....	
Seven Persons River.....	ikitsika-etapix.....	
Rocky Mountains.....	mis-tokis.....	Porcupine tail.
Porcupine Hills.....	ky-cs-kaghp-oghsuyiss.....	
Buffalo Fat Pound Coulee (on the Belly River, } five miles above Dutch Fred's).....	pomi-piskan-kawagh-kway.....	
On river $1\frac{1}{2}$ miles below Fort MacLeod, also } above Blackfoot Crossing.....	nimex.....	The bank abreast of the wind.
Whoop Up.....	akka'-inow-skway.....	Many Blood Indians died.
Forks of the Bow and Belly Rivers.....	omak-etaow-towugty.....	Big forks.
The Elbow.....	moki-nist-sis.....	Painted rock.
Near Coal Banks, (right bank of river).....	mek-kio-towaghs.....	Many woodpeckers.
Elbow of Belly River (30 miles east of Coal Banks).....	akka-kima-to-kway.....	The beard.
The Chin (of map).....	misto-amo.....	
Belly River.....	mokowamis-etugty.....	
Butte.....	no ko-an-etomo.....	

Turnip Butte.....	mas'-etomo.....	
Ridge between Belly and Waterton Rivers.....	sitoko-pawaghkway.....	The ridge between the rivers.
Blackfoot Crossing.....	soyogh-pawaghkway.....	Ridge below the water.
Cherry Coulee.....	ami-onaskway.....	Berries up the hill-side.
Far-out Coulee (on Belly River).....	piyami-pawaghkway.....	
Drift-wood Bend.....	akka-kowatchis-kway.....	Drift-wood place.
Above Coal Banks, right bank.....	assini-etomotchi.....	{ Where they slaughtered the Crees. (?)

Turnip Butte.....	mas'-etomo.....	The ridge between the rivers.
Ridge between Belly and Waterton Rivers.....	sitoko-pawaghkway.....	Ridge below the water.
Blackfoot Crossing.....	soyogh-pawaghkway.....	Berries up the hill-side.
Cherry Coulee.....	ami-onaskway.....	
Far-out Coulee (on Belly River).....	piyami-pawaghkway.....	Drift-wood place.
Drift-wood Bend.....	akka-kowatchis-kway.....	{ Where they slaughtered the
Above Coal Banks, right bank.....	assini-etomotchi.....	{ Creeks. (?)
Black Spring Ridge.....	sitoko-kghis-kom-pawaghkway.....	
Scabby Butte.....	api-kmimikway.....	
The Valley, south of Chin Coulee.....	etzi-kom.....	Little rolling hills by the river.
About 35 miles below Blackfoot Crossing on Bow.	nitzi-tohtzi-pekiskway.....	Where the beaver cuts wood.
Beaver Creek.....	kak-gghik-stakiskway.....	The lodges with crows painted.
Crow Lodge Creek (enters Old Man, opposite)	ataw-is-toik-akawpi, or }	
Peigan agency.....	mastowisto-ok-oka-pi }	
South-east spur of the Porcupines.....	otsi-tchiksis-apikimikway.....	{ The ridge that slopes down to
Bad Lands near mouth of Bow River.....	agh-pao-tagh-ka.....	{ the river.
Long Lake (at junction of Chin and Seven)	eno-kimi.....	Ground over ground.
Persons Coulee.....	oh-maki-ya-kotop, or oh-man-okotok	
The Big Cairn (near mouth of Bow River).....	eht-si-manis.....	Thigh flesh.
Parflese Creek (Crowfoot Creek).....	motuksina.....	Place of many snakes.
Thigh Hills.....	ak'-ustsik-simiskway.....	Arrow-wood place.
Snake Creek.....	nehls-ziks-kway.....	{ The beautiful hill that can
Arrow-wood Creeks.....	ists-sa-natskimikway.....	{ be seen from afar.
The Beautiful Butte, near Pi-yami Coulee.....	a-natskimikway.....	The beautiful hill.
Picture Butte, near Pi-yami Coulee.....	ehs-sin-no-kaka.....	Where they hunt the elk.
Seven miles above Whoop Up.....	eh-issa-kaghko.....	Left hand cut bank.
Three miles above Fort Kipp.....		

PLACES WITHIN THE AREA COVERED BY THE ACCOMPANYING MAP, &c.—Continued.

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
Many Berries Coulee (between mouth of Bow River and Cherry Coulee).....	ako-niskway	
Many Rosebuds River.....	ako-kiniskway	
Spy Hill (three of this name—one at Calgary, opposite the Nose; one between Coal Banks and Rocky Coulee; one N. of Red Deer River).....	sah-a-misapi	
Middle Butte (near mouth of Highwood River).....	eh-tutzeh-kigh-kimi-kway	
Sounding Lake (two of this name—one near Hand Hills and one between Little Bow and Bow River).....	oghta-kway.....	
Big Grass Marsh (at head of second Sounding Lake).....	o-mu'-kulzi-mook.....	
Stone Rib Creek (north of Red Deer River).....	sch-soo-wa-taghs	The rock without ribs.
Berry Water Lake (between Blackfoot Crossing and Little Bow, on road).....	nimi-oghkee	
Rocky Buttes (between St. Mary and Belly Rivers).....	okotok-skway	
Lake, between Blackfoot Crossing and Red Deer River (Tide Lake).....	awy-kimiska	The lake that runs up and down.
The Rainy Hills.....	sotah-ygh kimi-kway	
A point between Blackfoot Crossing and Red Deer River.....	ponoka-emila-omukty-neep	Where the horse died.
Fort MacLeod.....	stamix-otokan-okowy	Bull's head's home.
Fort Calgary.....	mok-kinists-in'-aka-apewis	
Shaganappé Point (above Calgary).....	eh-naok-keet-tox-kway.....	Halt point.

The Old Man's Red (on the Red Deer, near the Rosebud River).....	napia-okanes	
Leaning Hill (between Blackfoot Crossing and Red Deer River).....	kegh-keep	Propped up hill.
Above Calgary, on the Bow	inew-teneks-is-dop	{ Where the buffalo run down the hill.
Fishing Lake (near Hand Hills).....	mamis-kway.....	{
A point on Red Deer River	eh-faka-okeneema	{ Where many lodges of the

The Old Man's Bed (on the Red Deer, near the Rosebud River)	napia-okanes	Propped up hill.
Leaning Hill (between Blackfoot Crossing and Red Deer River)	kegh-keep	{ Where the buffalo run down the hill.
Above Calgary, on the Bow	inew-teneks-is-dop	{
Fishing Lake (near Hand Hills)	mamis-kway	{ Where many lodges of the dead are.
A point on Red Deer River	eh-taka-okeneema	{
Jumping Buffalo Hill (on the Bow River)	otse-tchik-sia-pagh-ki-ote-sch	
The Inner Rainy Hills	pists-sotah-ygh-kimi-kway	
The Inner Big Cairns (in Rainy Hills)	pists-omakiya-kotop	
Bad Water Lake	pak-oghkee	
Sarcee Plain	sarcee-sowkee	
Picture Rocks (on stream at Big Hill above Calgary)	omisnah	
St. Mary River	opoghto-maxi-kimi-tughty	South Big Lake River.
Old Man River	{ napia-otzi-kagh-tzipi, or }	
Milk River	kinok-kxis-ughty	Little river.
Highwood, or High River	spitzii	Medicine lodge.
Fish Creek	stokan	River with rapids.
Ghost River	opskoonakaz	Strawberry Hills.
Sweet Grass Hills	katoyis	
Hand Hills	oh-tchis-tchis	
The Nose (above Calgary, on opposite side of river)	mok-sis-sis	
Big Hill, or Blackfoot Hills (east of Calgary)	o-muk-etomo	
and north of Bow River)	aka-waskway	Many eggs place.
Egg Lake (in Hand Hills)	pinozti-piskan	
Enemy's Pound (on east side of Porcupine Hills)		

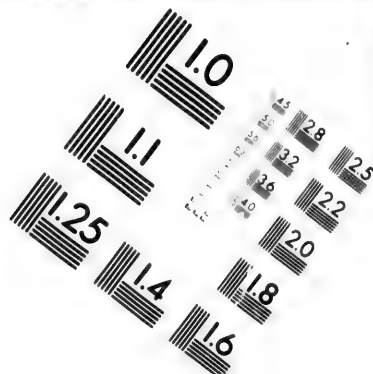
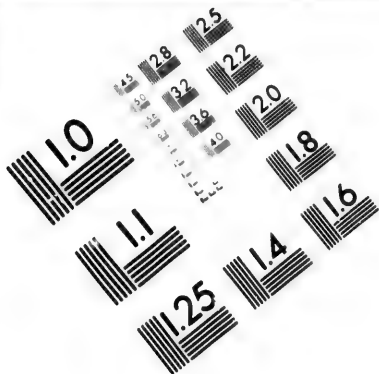
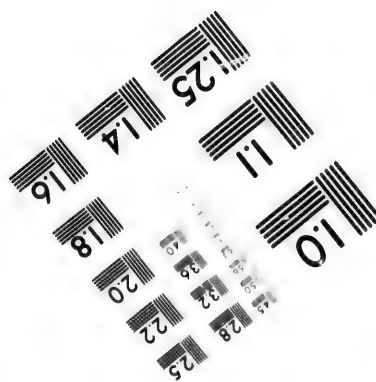
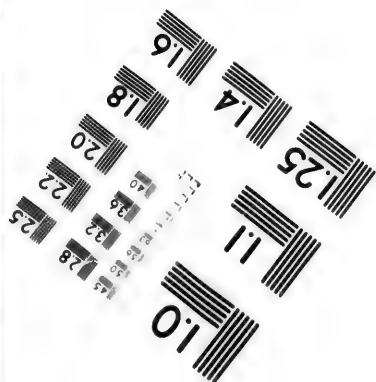
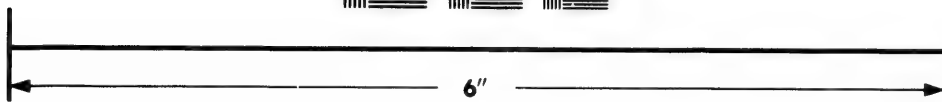
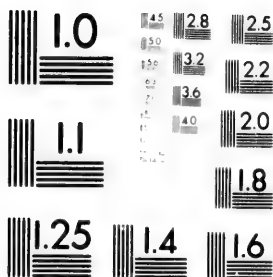


IMAGE EVALUATION TEST TARGET (MT-3)



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PLACES WITHIN THE AREA COVERED BY THE ACCOMPANYING MAP, &c.—*Concluded.*

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
Crow's Stone Hill (on Red Deer River, north of Blackfoot Crossing).....	ma-to-wy-oka-etomo.....	
Wolf's Peak (four miles above Whoop Up).....	muk-kwy-otehekan.....	
Buffalo Pound Creek (east side of Porcupine Hills).....	ehtzi-pāk-si-kini-kawts.....	{ Where we smashed their heads in the mud.
Tasting Lake (east side Porcupine Hills).....	mata-pokway.....	
Ghost Pound (east side of Porcupine Hills).....	staow-piskan.....	
Woman's Pound.....	aki-piskan.....	Woman's Pound.
Men's Pound (Jucaping Pound River of map).....	nehts-is-omiopie.....	Where we approached the enemy.
The Lone Tree (on Peigan Reserve).....	nina-piskan.....	
Blood Green-water Lake (on or near Chin Coulee).....	ly-poy-yi.....	
Peigan Green-water Lake (on or near Chin Coulee).....	kinaow-oghke-komino-was.....	
Middle Heights (between Mosquito Creek and High River).....	peigani-oghke-komino-was.....	
Mosquito Creek.....	sitook-spagkway.....	
The White Precipice (on Elbow River, about 10 miles above Calgary).....	pak-si-may-so-yiskway.....	
The Plateau (above Calgary, on same side of river).....	{ istzcha-payks, or }	
Grassy Lake (half-way from Fort MacLeod to the Little Bow River).....	{ apa-zeaks-aghk. }	
Rocky Coulee (about 12 miles east of MacLeod, on Old Man River).....	spas.....	
Sheep Creek.....	moyi-kimi.....	
Tongue Flag Creek.....	ah-mistokiskway.....	
	matokxi-etughy.....	
	matzin-awastam.....	Rocky river.
The Drifting Sand Hills (above Blackfoot Crossing, on the Bow River).....	kasupō-spachikway.....	
Many Berries Creek (runs out of Bad Water Lake).....	aka-ehnikskway.....	
Sun Dial Hill.....	onoka-katzi.....	
Chief Mountain.....	nina-stokis.....	
Hunting Hill Coulee (on Bow R., below Big Cairn).....	sah-a-mi-sapi-kawagway.....	

Tongue Flag Creek.....

The Drifting Sand Hills (above Blackfoot Crossing, on the Bow River) }
Many Berries Creek (runs out of Bad Water Lake)
Sun Dial Hill.....
Chief Mountain.....
Hunting Hill Coulee (on Bow R., below Big Cairn)

kasapō-spatchikway.....
aka-ehnisikway.....
onoka-katzi.....
nina-stokis.....
sah-a-mi-api-kawaghway.....

PLACES EAST OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLIE RIVERS DISTRICT.

The Ford of the Drowned (on South Saskatchewan, 30 miles above mouth of Red Deer). }
Forks of the Red Deer River.....
The Gap (in Cypress Hills).....
Medicine Hat.....
The Great Sand Hills (north of Cypress Hills) }
The Middle Sand Hills (between Red Deer and South Saskatchewan Rivers) }
At Standing Hill, north of Cypress Hills, (bottom land of the South Saskatchewan).....
Standing Hill.....
Large Lake, north of Cypress Hills..... }
Red River..... }
The Forehead (Forks of Red Deer and Saskatchewan Rivers) }
Ghost's House (30 miles north-east of Cypress).....
Elk-water Lake (at head of Cypress).....
Wood Mountains.....
Eyebrow Hills.....
Fort Walsh.....

eh-ty-nehts-ope-piney.....
ponoka-si-oughty-ototughty.....
ā-ygh-kimi-kway.....
sah-a-mis.....
omaxi-spatchikway.....
sitoko'-spatchikway.....
agh-pot-sikimi.....
pi-is-koas.....
aka-'amuskiis-skway..... }
aka-naywass..... }
maokootzi-tughty.....
moh-nisey.....
sta-'apewis.....
ponoka-oghkee.....
ā-ygh-kimi-kw'iy.....
napisp-piw'-tomo.....
ā-ygh-kimi-kway-in-aka-apewis.....

Where we were drowned.

Where it overflowed.

Many lizards or many islands lake.

Gap in the hills.

PLACES NORTH OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
Edmonton	amakowis	The big house.
Fort Pitt	eh-tutzi-kugh-s-apewis	
Battleford	kenoksis-is-ugh'-y-oto-tughty	
Fort Carlton	napiia-poka-okowy	White man's child's house.
Little Red Deer River	asino-ka-sis-ughty	
The Head Pine (on road from Calgary to Rocky Mountain House)	olokan-exi	
Battle River	kinok-kxis-sis-ughty	
Bear Hill (30 miles south of Edmonton)	kyo-etomo	Little or half river.
Beaver Hill (near Fort Saskatchewan)	kaghghik-staki-etomo	
Neutral Hills	kghx-yx	
Rocky Mountain House	a-l'-astan	
Wild Cat Hills, (E.N.E. of Morley)	natayo-paghsin	
Macpherson's Coulee (21 miles north of Calgary)	namaghkaues	Rifle bed.
North Saskatchewan River	omaka-ty	Big river.

PLACES WEST OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

Country beyond the mountains	sat-tos	Across the mountains.
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PLACES SOUTH OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

The Knees (on Benton trail)	motuksis	
Marias River	kyo-eis-ughty	Bear river.
Missouri	amiskapo'omakaty	Big south river.
Yellowstone	ponakasis-ughty	Elk river.

PLACES SOUTH OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

The Knees (on Benton trail)	motuksis	
Marias River.....	kyo-eis-'ughty	Bear river.
Missouri	amiskapo'omakaty	Big south river.
Yellowstone	ponakasis-'ughty	Elk river.
Bear's Paw (in Montana)	kyo-'tsis	
Little Rocky Mts. (in Montana, near Wolf Hills)	muck-kwyé-stokkis	Great cactus plain.
Helena	aka-ota-kotsis	Many river forks.
Diamond City	aka-oto-'ughty	South many houses.
Fort Benton	amiska-poghts-aka-apewis	White-tail deer lodge.
Deer Lodge	awatuyé-okowy	

NAMES OF PLACES WHOSE EXACT POSITIONS ARE UNKNOWN.

Little Blackfoot Crossing	enax-soyogh-pawaghkway	
The Lone Point of Trees (on Red Deer River)	nitoks-kaskway	
Wild Cat Pound	natayo-piskan	
Pemmican Hill (on Red Deer River)	moka-keh-etizato-ope	
Many Cherry Bushes Valley	aka-onaskway	
Elk River	ponokasis-'ughty	
Three Hills	nioka-etomox	
Pigeon Hill	mom-mo	
Dried Meat Hill	kyé-'tomo	
Willow Hill	pak-kitze-kimi-kway	
Snake Hill	piksisina-oksisis	
Buffalo Lake	ini-'oglukee	
Coulée above Medicine River	py-yotami-kawaghkway	The coulée coming this way.

Where we lost the pemmican.

Names of Places whose Exact Positions are Unknown.—Continued.

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
The Horns.....	oht-skanaix	Where the orphans were cold.
Muddy Bed.....	pak-sikkagbko-kanes	
Red Rock.....	maok-skoisteh	
The Orphans' Place.....	eh-is-tuyé-pokaex	
Where He Slept.....	eh-to-kitzi-keenis-staow-pee	
The Peigan's Hill.....	sah-ami-es-kapeep	
Big-mouthed Spring	sokoge-oksis-kom	
Lake Pound	omuk-sikimi-piskan	
Timber Incline.....	matsi-pa-sat-sikway	
Eagle Hill	pitah-etomo	
Beard Spring (north of Red Deer River).....	misto-kxis-kom.....	

NOTE.—The following names of places were obtained by myself from Blood Indians known as Bull Shield and Button Chief. In these the vowels have the "Continental" values and the spelling generally is conformable to that employed in vocabularies previously published by the Survey.—G. M. D.

St. Mary River.....	pa-toxi-a-pis-kun ..	Banks damming the river.
Belly River.....	mo-ko-in-se-to-to	

NOTE.—The following names of places were obtained by myself from Blood Indians known as Bull Shield and Button Chief. In these the vowels have the "Continental" values and the spelling generally is conformable to that employed in vocabularies previously published by the Survey.—G. M. D.

St. Mary River.....	pa-to-xi-a-pis-kun	Banks damming the river.
Belly River.....	mo-ko-un-se-te-ta	
Chief Mountain	min-ai-sto-kwa.	
St. Mary Lake	puh-to-mux-okun.....	
Old Man River.....	na-to-ke-okos.....	Two medicine lodge.
Pincher Creek.....	in-oks-spit-zi	Little high wood river.
Willow Creek.....	stai-a-pis-kun	
Porcupine Hills.....	kai-ekop-o-soi-us	
Milk River	ki-nuh-si-subt.....	The little river.
Milk River Ridge	amuh-pow-ekwi	
Belly Butte.....	mo-ko-ons.....	The belly.
Blackfoot Crossing.....	soi-a-poh-kwe	
Little Bow Water.....	na-muh-tai	
Bad Water Lake	pa-kow-ki	
Seven Persons Coulee.....	ki-tsuki-a-tapi	
Bull's Head Hill.....	inc-o-to-ka	
Cypress Hills	ai-ekun-ekwe.....	
Sweet Grass Hills	kat-e-is	
Medicine Hat.....	sa-a-mis.....	

APPENDIX III.

The following are partial analyses by Mr. G. C. Hoffmann, of specimens of clay ironstone, derived from the rocks of the district embraced by the foregoing report. These analyses are quoted from the Report of Progress, 1880-82.

Bow River, eight miles above Grassy Island, (p. 90 c.)

Ferrous oxide	40.347
Ferric oxide.....	.878
Water, hygroscopic856
Insoluble residue	16.121
Metallic iron, total amount of.....	31.996

Bow River, twelve miles above Prairie Island, (p. 91 c.)

Ferrous oxide	28.818
Ferric oxide.....	.818
Water, hygroscopic938
Insoluble residue	13.935
Metallic iron, total amount of.....	22.987

Kananaskis or Rapid River, near its confluence with Bow River, (p. 107 c.)

Ferrous oxide	13.786
Ferric oxide.....	.772
Water, hygroscopic473
Insoluble residue	66.966
Metallic iron, total amount of.....	11.263

Belly River, at Coal Banks, (p. 72 c.)

Ferrous oxide	41.458
Ferric oxide328
Water, hygroscopic	1.042
Insoluble residue	10.294
Metallic iron, total amount of.....	32.475

Belly River, about seven miles below Coal Banks, (p. 73 c.)

Ferrous oxide	30.730
Ferric oxide.....	1.398
Water, hygroscopic	1.272
Insoluble residue	23.754
Metallic iron, total amount of	24.880

CAWSON.]

Belly River
Bow River, (

Ferrous
Ferric
Water
Insoluble
Metallic

Mill Creek,

Ferrous
Ferric
Water,
Insoluble
Metallic

Belly River, about seventeen miles east of the mouth of the Little Bow River, (p. 74 c.)

Ferrous oxide	30.302
Ferric oxide.....	1.487
Water, hygroscopic	1.445
Insoluble residue	12.120
Metallic iron, total amount of.....	<u>26.165</u>

Mill Creek, at coal outcrop, about four miles above the mill, (p. 99 c.)

Ferrous oxide	37.985
Ferric oxide.....	.811
Water, hygroscopic634
Insoluble residue	12.511
Metallic iron, total amount of.....	<u>30.112</u>